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# Final Environmental Impact Statement

# **VEGETATION MANAGEMENT**

# **in the Coastal Plain/Piedmont**

## **VOLUME I**





## COMMENTS ON THE METRIC SYSTEM

The metric system is used to describe weights and measures. It is a decimal system -- units are consistently named to reflect multiplication or division of the basic unit by some power of 10 (10, 100, 1000, etc.). The two basic defined units of this system are the meter and the kilogram. All other units (volume, area, etc.) are calculated based on these two.

Metric measurement is the standard for scientific communication worldwide. It has been selected in preference to many other systems including the English system of measures which is in common use in the United States. Below is a table which will help readers of this Risk Assessment understand the metric numbers presented throughout the text.

### ABBREVIATIONS (Metric and English)

ac = acre	kg = kilogram	ml = milliliter
cc = cubic centimeter	km = kilometer	mm = millimeter
cm = centimeter	l = liter	ppm = parts per million
ft = foot	lb = pound	
g = gram	m = meter	oz = ounce
ha = hectare	mg = milligram	qt = quart
in = inch	mi = mile	um = micrometer

### CONVERSIONS

#### Length:

METRIC to ENGLISH	ENGLISH to METRIC
1 km (1,000 m) == 0.6214 mi	1 mi == 1.609 km
1 m == 39.37 in	1 ft == 0.305 m
1 cm (.01m) == 0.394 in	1 in == 2.54 cm
1 mm (.001m) == 0.0394 in	
1 um (.000001m) == 0.000039 in	

#### Mass / Weight:

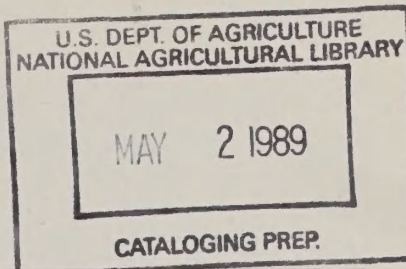
1 kg (1,000 g) == 2.2046 lb	1 lb == 453.592 g
1 g == 0.035 oz	1 oz == 28.35 g
1 mg (.001 g) == 0.000035 oz	
1 ug (.000001 g) = 0.000000035 oz	

#### Others:

1 l == 1.056 qt (liquid)	1 qt == 1.136 l
1 ha == 2.471 ac	1 ac == 0.40 ha
1 kg/ha == 0.89 lb/ac	1 lb/ac == 1.12 kg/ha



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# FINAL Environmental Impact Statement for

## VEGETATION MANAGEMENT

### in the Coastal Plain/Piedmont

USDA Forest Service | Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina,  
Southern Region | South Carolina, Texas

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#### Abstract

This environmental impact statement presents nine alternative ways to manage vegetation on Coastal Plain/Piedmont national forests of the USDA Forest Service's Southern Region. These alternatives range from no treatment to maximum vegetation control. Treatment alternatives use different mixes of methods and vary numbers of acres treated so as to present a wide array of possible approaches. Effects of each alternative on the physical and biological environment and on social and economic conditions are presented. Alternative Modified G is the Forest Service's preferred alternative.

#### Note To Reviewers

Reviewers have an obligation to structure their participation in the National Environmental Policy Act process so that it is meaningful and alerts the agency to reviewers' positions and contentions, *Vermont Yankee Nuclear Power Corp. v. NRDC*, 435 U.S. 519, 553 (1978). Environmental objections that could have been raised at the draft stage may be waived if not raised until after completion of the final environmental impact statement, *Wisconsin Heritages, Inc. v. Harris*, 490 F. Supp. 1334, 1338 (E.D. Wis. 1980). Comments should be specific and should address the adequacy of the statement or merits of the alternatives discussed.

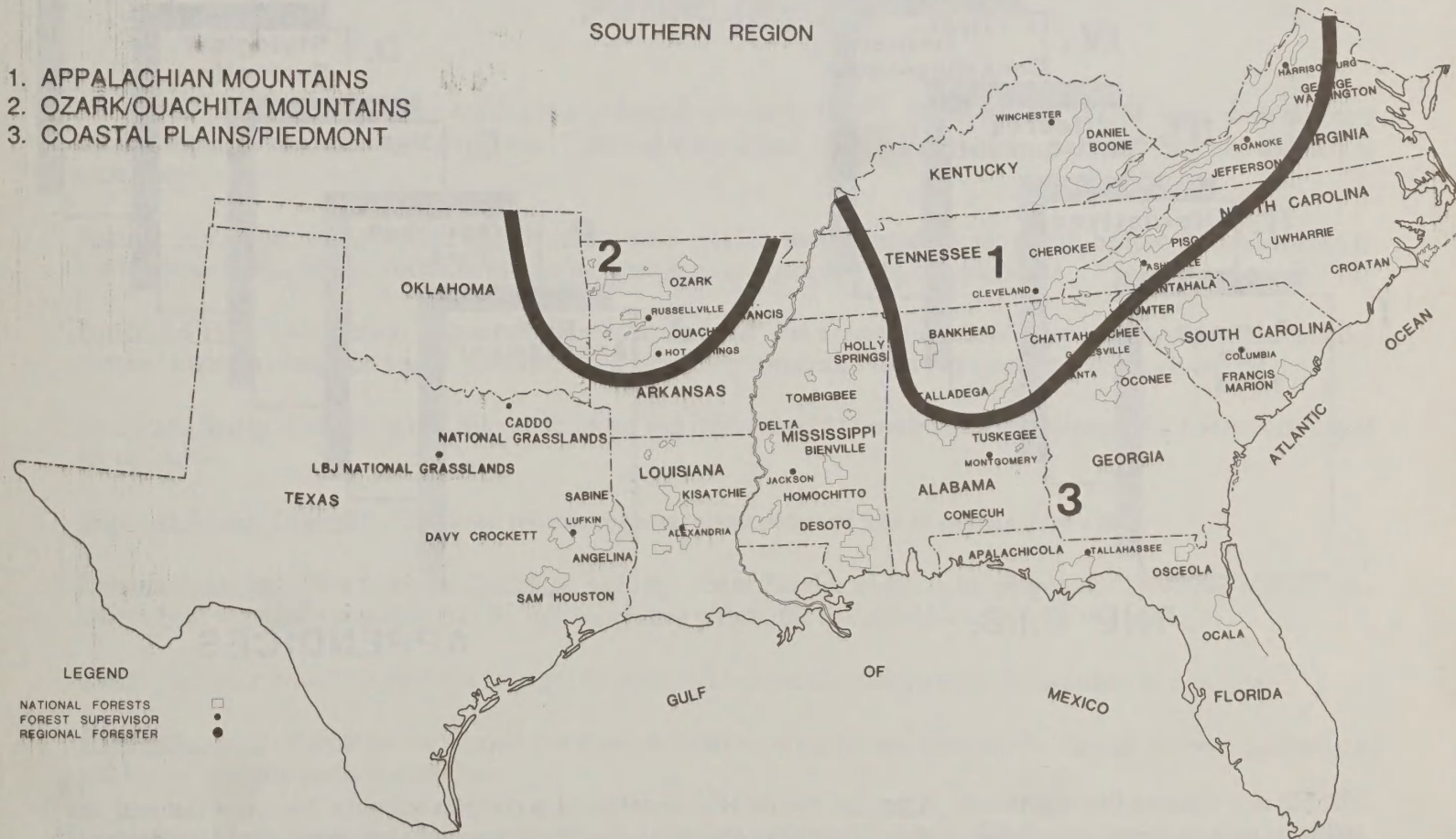




# SUMMARY

## Introduction

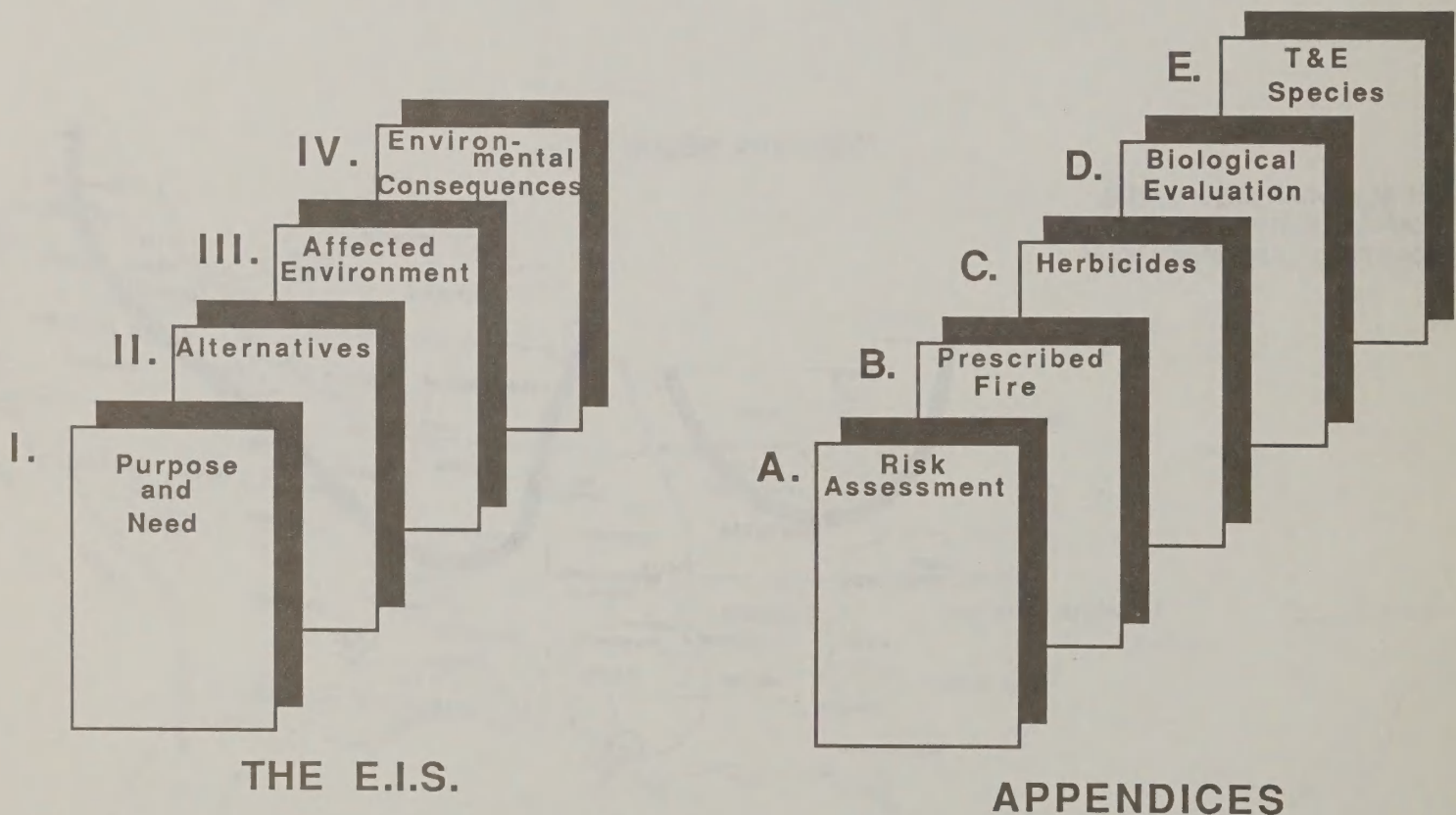
This summary introduces you to the Environmental Impact Statement (EIS) for vegetation management on national forests and national grasslands in the Coastal Plain/Piedmont. This area includes all of Florida, Louisiana, Mississippi, and Texas, and parts of Alabama, Georgia, North Carolina, and South Carolina.



Vegetation management is the manipulation of plants to help young trees survive and grow, to provide a variety of wildlife habitats, to maintain plants used by grazing animals, to reduce hazardous fuels, and to maintain safe and efficient travelways and utility lines.

The EIS analyzes effects of vegetation management methods on human health and safety, wildlife and aquatics, threatened and endangered species, vegetation, soil, water, air, rights-of-way, visual quality, cultural resources, wildfire, and social and economic conditions. Based on issues raised by the public, the document evaluates nine alternatives that differ with respect to acres treated, mix of methods, and intensity of tools available in each method. **Modified G is the preferred alternative.** This alternative increases use of prescribed fire and herbicides for vegetation management, decreases use and intensity of mechanical methods, and introduces limited use of aerially applied herbicides. Prescribed fires are low to moderate intensity, and herbicides and application methods that pose minimum risks to humans, wildlife, and non-target plants are emphasized. Herbicide use is more selective (target-specific) than present.

Chapters I through IV form the heart of the EIS. Chapter I defines the scope of decisions and displays issues. Chapter II explains each alternative, describes methods and tools, prescribes measures to mitigate adverse environmental effects, and compares alternatives. Chapter III describes the environment of the Coastal Plain/Piedmont. Chapter IV presents detailed analyses of environmental effects based on extensive scientific research. This summary presents highlights of these chapters.



The EIS also contains five appendices. Appendix A is the Risk Assessment, a complex scientific document that analyzes herbicide risks to human and wildlife health. These risks are a product of the potency of each chemical and the degree of exposure to it. The evaluation compares herbicide doses people and animals may get with doses shown to be safe in laboratory studies. Risks are evaluated for workers, the public, and terrestrial and aquatic animals. Each herbicide is analyzed for its potential to cause toxic and other effects such as cancer, mutations, and birth defects. Appendices B and C discuss the effects of prescribed fire and herbicides on soil and water. They contain large bodies of research data under one cover and thus improve ease of accessibility for readers interested in the technical analyses. Appendix D is a biological evaluation of the effects of the preferred alternative on threatened, endangered, proposed, and sensitive species, and Appendix E lists these species.



# Scope of Decisions

The Southern Region contains a variety of landscapes, plant communities, soil types, and climates. To account for some of these differences, the Region is divided into three areas to analyze vegetation management activities. This EIS covers the Coastal Plain/Piedmont area. Other EIS's will cover the Appalachian Mountains and Ozark-Ouachita Mountains.

This EIS accepts the land allocation and resource output decisions of the Forest Land and Resource Management Plans. It evaluates various vegetation management methods and tools needed to achieve Plan goals. The makeup of methods, tools, and mitigation measures in the selected alternative may require some changes in Plan direction.

This EIS analyzes general effects over broad areas. Since environmental conditions can vary greatly from site to site, each project must be evaluated for its own site-specific effects. The site-specific analyses may reference (tier to) this EIS and EIS's accompanying Plans as appropriate. Methods and tools available for use on the ground are limited to those specified in the selected alternative.

## Public Issues

Nearly 900 people responded to a request to help identify 11 issues the EIS should address. These issues form the basis for developing and comparing alternatives. They express multiple concerns and values, many of which are opposed to each other.

Balance of Resources: At issue is the mix of resources and outputs produced. Some people believe that an increase in market outputs, like timber, conflicts with an increase in non-market outputs, like aesthetics.

Prescribed Fire: This method is generally viewed as "natural" and needed for wildlife, some ecosystems, and wildfire control. Concern centers on season, frequency, and intensity of prescribed fires as they affect soil, water, and air.

Health and Safety: Concern is that risks of accidents and illness should be evaluated and minimized for forest workers and for the public.

Plant and Animal Diversity: This issue reflects concerns about potential loss of species from a site.

Communications: This issue involves how well the Forest Service explains its programs. The issue applies only indirectly to vegetation management. By fully disclosing effects, the EIS should help address this issue.

Costs: This issue reflects desires that low-cost methods be used and that employment opportunities be provided.

Soil Productivity: People are concerned that some methods may impair soil productivity through erosion, compaction, and loss of nutrients and soil organisms.

Herbicides: Many people feel that herbicides may have serious effects on human health and non-target plants and animals.

Aerial Application: Some people feel that aerially applied herbicides increase risk to human health and non-target plants and animals. Others view it as essential for economical treatment of some areas.

Wildlife: This issue reflects concerns about potential adverse effects on game, non-game, and threatened and endangered species, and desires that vegetation be managed to enhance wildlife habitat.



# Affected Environment

This EIS covers 4.6 million acres, on 23 national forests and two national grasslands, in the Coastal Plain/Piedmont. The Coastal Plain contains a flat lower segment along the coasts and the Mississippi River, a rolling middle segment, and a hilly upper segment. The Piedmont is a rolling to hilly upland dominated by eroded clay soils. The humid subtropical climate has hot, humid summers, mild winters and ample rainfall.

Major vegetation groups are the oak-hickory-pine (loblolly-shortleaf pine) forests, southern mixed and sand pine scrub (longleaf-slash pine forests, southern floodplain (bottomland hardwood) forestes, and tallgrass prairies. There are 15 animal species and four plant species classified as threatened or endangered. Soils deficient in organic matter and nutrients occur mostly in the Piedmont, Upper Coastal Plain, loess (wind-deposited) uplands, and Florida. Aquifers yielding ample ground water are abundant in the Coastal Plain but scarce in the Piedmont. Most lakes occur in Florida, and most wetlands occur in the Lower Coastal Plain.

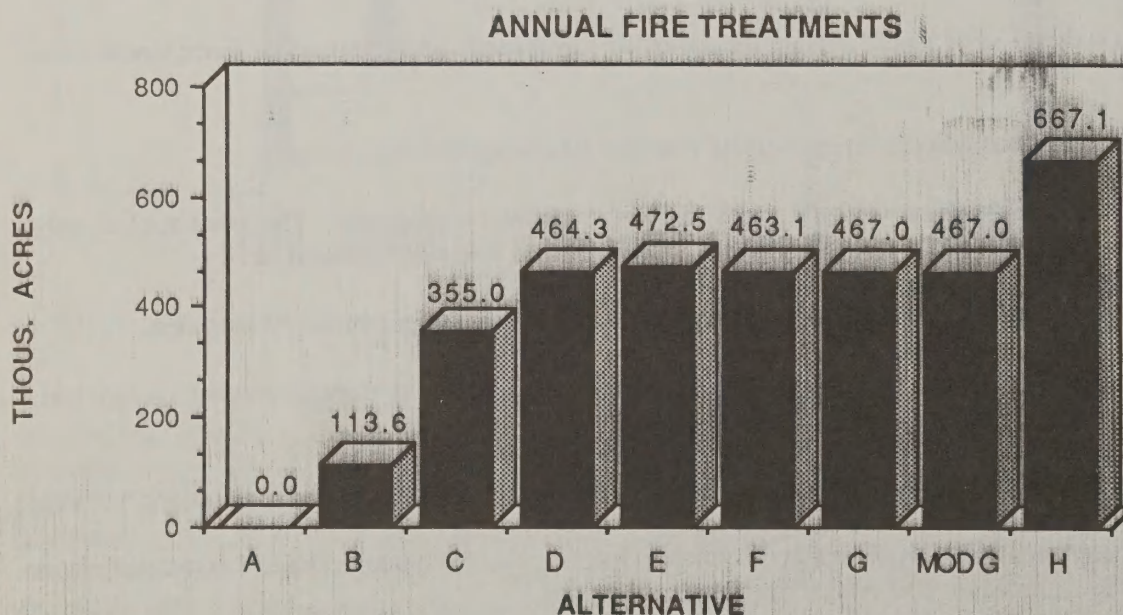
Vegetation management is presently planned for an average of 553,500 acres per year, or 12 percent of national forest lands in the Coastal Plain/Piedmont. Of this total, 463,000 acres (86.3 percent) are now treated by prescribed fire; 59,000 acres (10.7 percent) by mechanical methods; 27,000 acres (4.9 percent) by herbicides; and 4,500 acres (0.8 percent) by manual methods. Biological methods are not used at present.

## Vegetation Management Methods and Tools

The five methods evaluated by the EIS are prescribed fire, mechanical, manual, herbicides, and biological. The mix of these methods varies markedly by alternative.

### Prescribed Fire

Prescribed fire is the planned use of fire under specific conditions. Six firing techniques are used that vary how a fire is set in relation to the wind. Prescribed fires may be set by hand using drip torches or by air using helicopters.

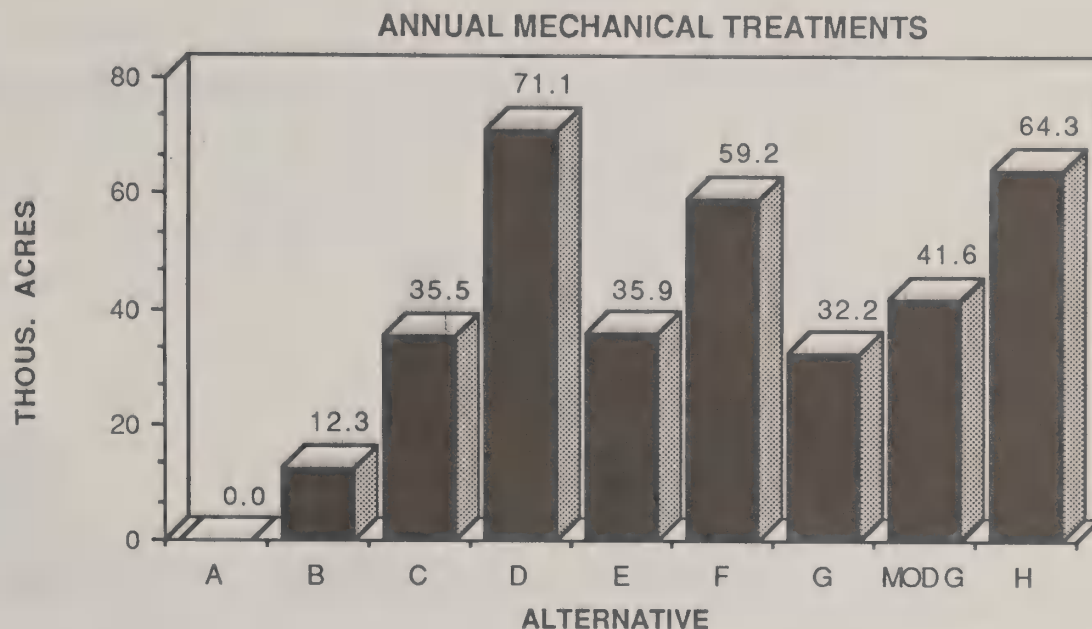


### Mechanical Methods

Mechanical methods involve the use of ground machines. They are classed into three groups based on their potential for soil disturbance by erosion, compaction, and nutrient loss.

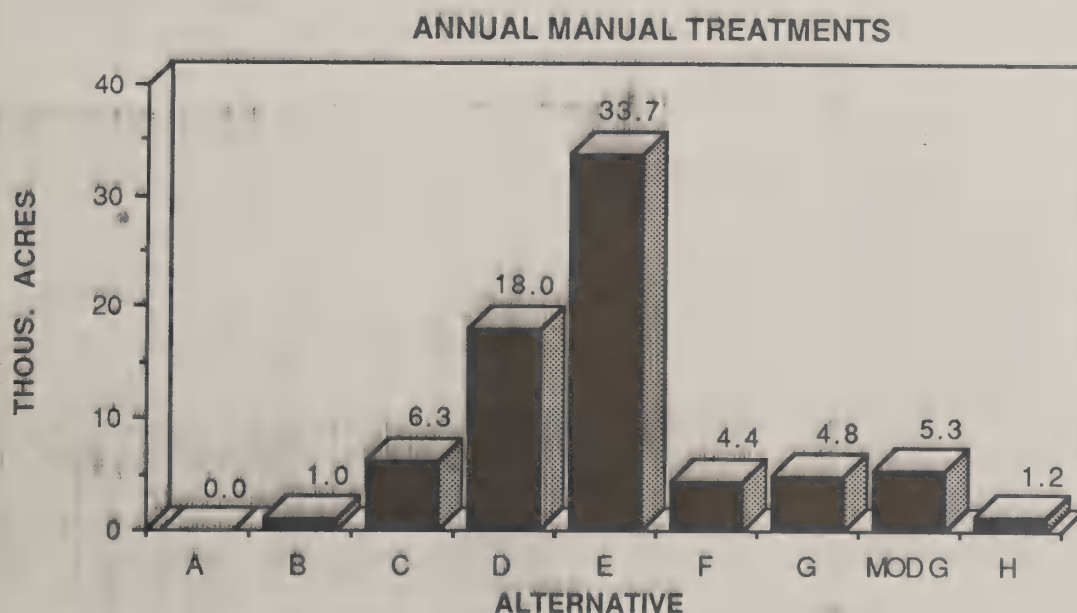


Mowing tools cut small vegetation above ground. Chopping tools are bladed drums that roll over and chop vegetation. Shearing tools are tractor-mounted blades that cut vegetation above ground. Scarifying tools scoop small depressions in the soil at wide intervals. Ripping tools plow furrows at wide intervals. These tools cause low soil disturbance.



Piling and bedding cause moderate soil disturbance. Piling tools replace dozer blades on tractors and roll vegetation, slash, and some litter into piles or windrows. Bedding tools are used on flat sites and pile topsoil and litter into elevated beds.

Raking and disking cause high soil disturbance. Unlike piling tools, raking tools push all litter and some topsoil into piles or windrows. Disking tools are used on slopes up to 20 percent and loosely till the soil.

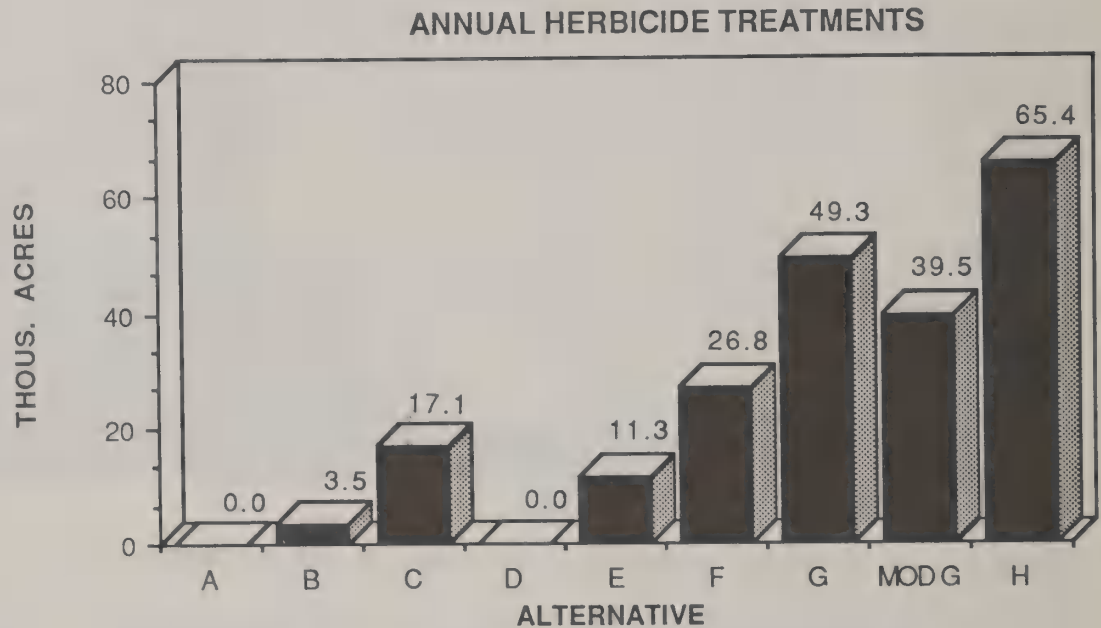


### Manual Methods

Manual methods employ hand tools to cut vegetation above ground. Non-power tools are axes, brush hooks, and clippers. Power tools include chain saws and brush cutters.

## Herbicides

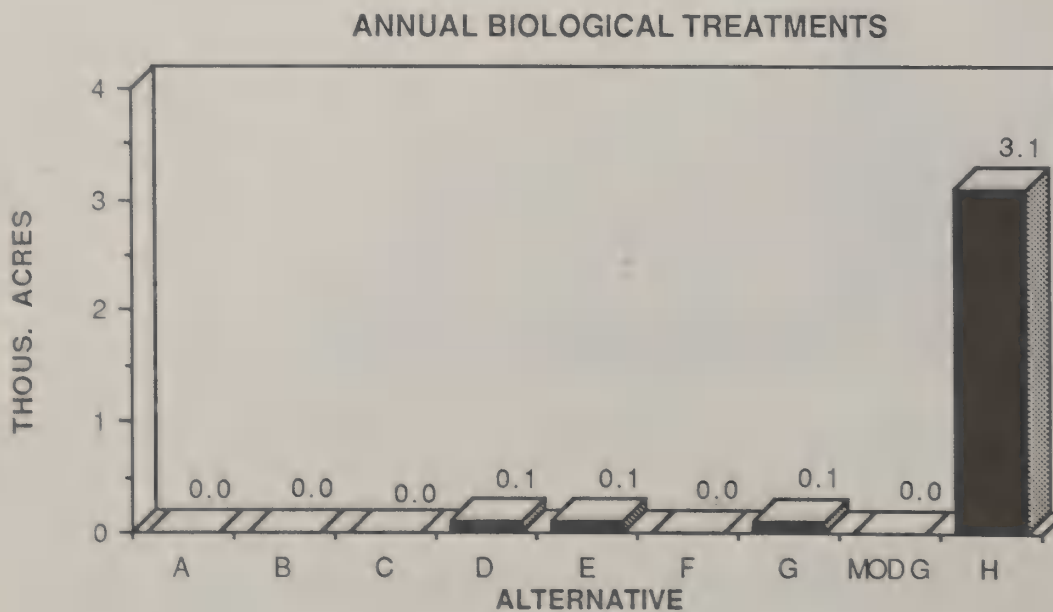
The 11 herbicides evaluated for use in the Southern Region are dicamba; fosamine; glyphosate; hexazinone; picloram; sulfometuron methyl; triclopyr; 2,4-D; 2,4-DP; imazapyr; and tebuthiuron. In addition, 3 additives (diesel oil, kerosene, and limonene) are analyzed for their effects on human and wildlife health.



Herbicides are used to kill or suppress target plants. They are applied in liquid or granule form by hand, machine, or air. Hand applications use backpack sprayers and tree injectors for liquids and hand-held spreaders for granules. Machine and helicopter applications use boom/nozzle sprayers for liquids and power spreaders for granules.

## Biological Methods

The only biological method evaluated is the use of livestock within existing grazing allotments for pine release.





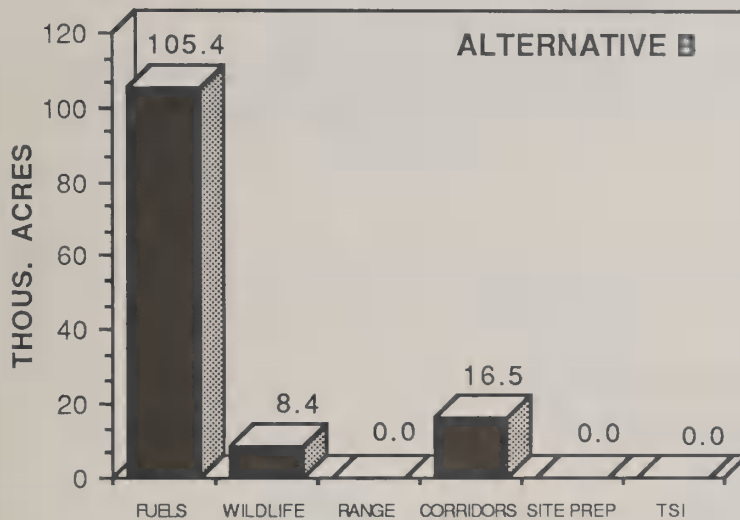
# Alternatives

Nine alternatives were developed to respond to issues. They vary by acres treated per year, mix of methods, and intensity of tools used in each method.

## Alternative A (No Action)

Vegetation management is not done. Existing vegetation is allowed to grow without manipulation.

## Alternative B

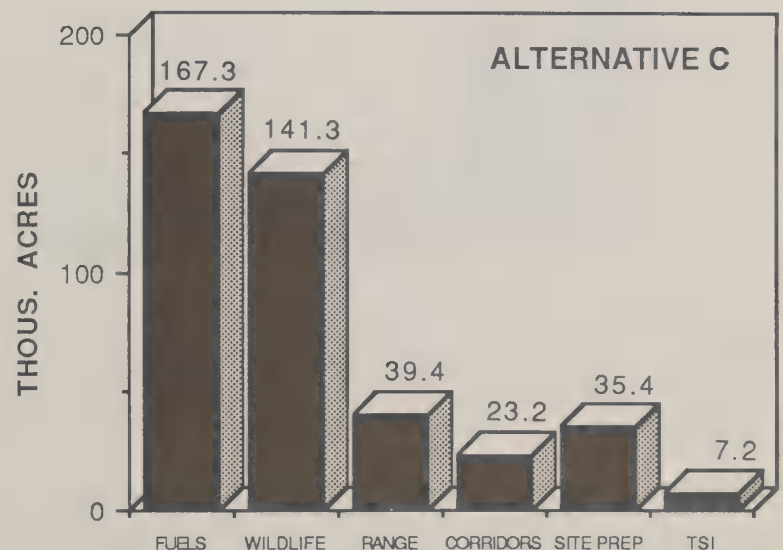


Vegetation management is done only to protect resources and public health and safety. Activities are limited to hazard fuel reduction, corridor maintenance, and protection of threatened and endangered species. Projected acres treated per year total 130,200. Use of herbicides and manual methods is minor, and biological methods are not used.

Herbicides are applied by hand. Herbicides and application methods that pose minimum risks to humans, wildlife, and non-target plants are emphasized. Mechanical treatments are limited to mowing. Only low-intensity, dormant season prescribed fire is used.

## Alternative C

Vegetation management is restricted to methods that achieve minimum resource objectives. All activities receive treatments, but only when critically needed. Projected acres treated per year total 413,800. Emphasis on prescribed fire and manual methods increases slightly from present, and use of biological methods is minor.



Herbicides are applied by hand. Herbicides and application methods that pose minimum risks to humans, wildlife, and non-target plants are emphasized. Mechanical methods cause low soil disturbance. Prescribed fire is of low intensity.

## Alternative D

Herbicides are not used. Projected acres treated per year total 553,500. Manual and mechanical methods are projected to increase from present by 13,700 and 11,900 acres, respectively, to replace herbicides. Use of biological methods is minor.

Mechanical methods cause low to moderate soil disturbance. Prescribed fire is of low to moderate intensity.

## Alternative E

Manual methods and prescribed fire are favored for vegetation control. Projected acres treated per year total 553,500. Manual methods increase from present by 29,300 acres, and herbicides and mechanical methods are projected to decrease by 15,500 and 23,300 acres, respectively. Use of biological methods is minor.

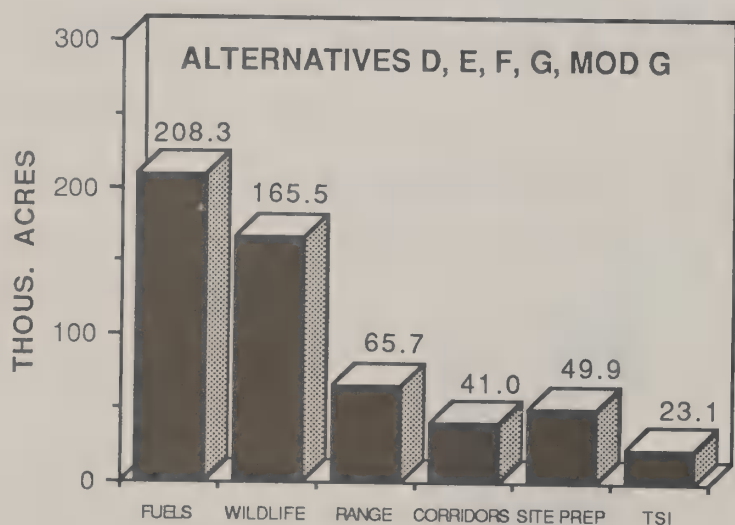
Herbicides are applied by hand and machine. Herbicides and application methods that pose minimum risks to humans, wildlife, and non-target plants are emphasized. Mechanical methods cause low to moderate soil disturbance. Prescribed fire is of low to moderate intensity.

## Alternative F

This alternative continues present levels of treatment specified in Forest Land and Resource Management Plans. Projected acres treated per year total 553,500. Use of manual methods is minor, and biological methods are not used.

Herbicides are applied by hand and machine. Mechanical methods cause low to high soil disturbance. Prescribed fire is of low to high intensity.

## Alternative G (Draft Preferred)



Prescribed fire and herbicides are favored for vegetation control. Projected acres treated per year total 553,500. Herbicides treatments are projected to increase from present by 22,500 acres, and mechanical methods decrease by 27,000 acres. Use of manual and biological methods is minor.

Herbicides are applied by hand, machine, and air. Herbicides and application methods that pose minimum risks to humans, wildlife, and non-target plants are emphasized. Herbicides are projected to be applied on 7,000 acres annually. Mechanical methods cause low to moderate soil disturbance. Prescribed fire is of low to moderate intensity.

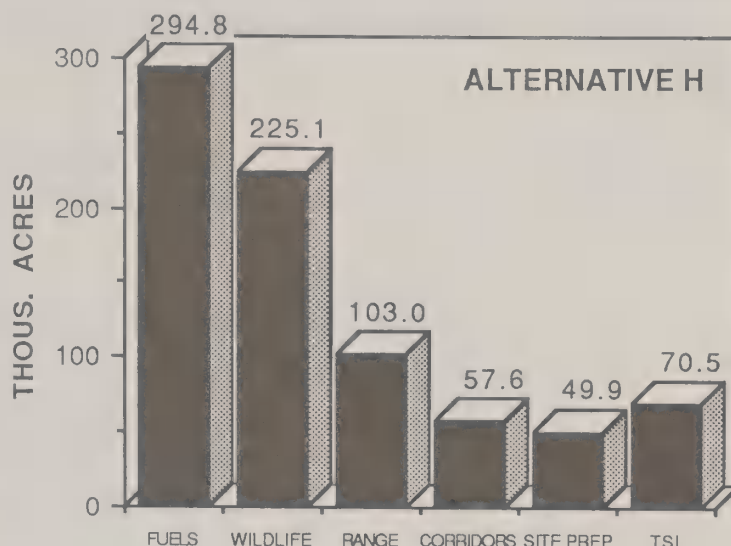
## Alternative Modified G (Final Preferred)

This alternative modifies alternative G by reducing total use of herbicides, areal application of herbicides, and the proportion of herbicides applied by broadcast, rather than selective methods. It also eliminates use of biological methods. In all other ways, this alternative is identical to G. Prescribed fire and herbicides are still favored for vegetation control. Herbicides use is projected to increase from present by 12,700 acres, and mechanical methods decrease by 17,600 acres. Aerial application of herbicides is projected to be 2,500 acres per year.



## Alternative H

Vegetation management is done to achieve maximum vegetation control. Herbicides are broadcast at maximum effective rates, and intensive mechanical methods and prescribed fire are favored. Projected acres treated per year total 801,000. Emphasis on herbicides increases markedly from present, and biological methods are used aggressively.



Herbicides are applied by hand, machine, and air. Projected herbicide application is 28,000 acres per year. Mechanical methods cause low to high soil disturbance. Prescribed fire is of low to high intensity.

## Management Requirements and Mitigation Measures

Management requirements and mitigation measures are "do's" and "don't's" applied on the ground to assure that treatments accomplish their objectives and produce fewer adverse impacts and more benefits. Some requirements and measures are general and apply to all vegetation management methods. Others pertain only to one method. Analysis showed that they significantly reduce adverse environmental effects. Chapter II covers them in detail and discusses their effectiveness. They are summarized below.

### General

Detailed site-specific analyses, biological evaluations, integrated pest management, and water quality protection measures are required for all projects. Timber stand improvement guides promote healthy stand conditions. Stream stability is protected by retaining bank vegetation and preventing debris deposits. Cultural resources are inventoried and protected. Safety equipment is mandated for field workers. Methods and tools are matched to visual quality objectives, and treatments are timed to protect scenic values. Vegetation is treated to enhance variety of wildlife habitat and protect forage

### Prescribed Fire

Timing and intensity of burns are controlled to protect crop and wildlife trees and nesting animals, limit soil damage, and reduce erosion, sediment loads, and smoke emissions. Firelines are built and maintained to reduce erosion and sediment and protect wetlands. Burns are patterned to enhance variety of wildlife habitat.

### Mechanical Methods

Erosion and sediment are reduced by mandating slope limitations, contour tillage, buffers along streams, and prompt revegetation. Treatments are timed to limit soil compaction. Roads, trails, and ditches are kept free of debris.

### Herbicides

Choice of herbicide and method, rate, and timing of application are managed to reduce risks to humans, wildlife, and other environmental elements. Supervision and training of applicators are mandatory to reduce risks of accidents and exposure.

Protective clothing and safety equipment are mandated to reduce exposure. Drift of herbicides is reduced by using special spray nozzles and applying during favorable weather. Precautions are specified to reduce risk of spills and water or worker contamination. Non-target vegetation, threatened and endangered species, water supplies, and adjacent lands are protected by buffers.

### Biological Method

Stocking and grazing patterns are controlled to reduce damage to trees, soil, water, riparian vegetation, and stream banks.

## **Environmental Consequences**

Chapter IV presents detailed analyses of effects of vegetation management on various environmental elements. It also summarizes effects of alternatives on each element. The alternatives differ with respect to acres treated, mix of methods, and intensity of tools allowed. Each of these factors influences the type and severity of environmental effects. These effects are summarized below.

Alternative A treats no acres. Alternatives B and C treat increasing numbers of acres, employ all methods, and use only low-disturbance tools. Alternatives D, E, F, G, and Modified G treat the present number of acres detailed in Forest Land and Resource Management Plans. Alternative D eliminates use of herbicides. Alternatives D, E, G, and Modified G use low to moderate disturbance tools, while F also uses high disturbance tools such as severe slash burns, raking, and heavy disking. Alternative H treats the most acres, employs all methods, and increases use of high disturbance tools.

### Human Health and Safety

Herbicides and additives evaluated and approved for use pose risks which are acceptable by EPA standards when required mitigation measures are followed. However, 2,4-D, 2,4-DP and tebuthiuron pose risks to workers using backpack sprayers, and 2,4-D poses risks to mixer-loaders. These risks are caused by the greater exposure for these workers, and can be mitigated to acceptable levels by changing chemicals, reducing application rate or exposure time, or using waterproof clothing. In general, worker exposure is reduced by aerial application.

Accidental injuries from other methods pose greater risks to workers than health impacts from herbicides. Accidents are most common and severe with manual methods. Prescribed fire poses the next highest risk. Alternative A poses the lowest overall risk to human health and safety because no tools are used and risks are limited to wildfires.

### Wildlife

All herbicides and additives evaluated meet acceptable risk standards for terrestrial and aquatic wildlife when applied using typical rates and methods. When applied at extreme rates, six chemicals pose risks to some species. Accidental spills of some chemicals into surface waters poses risks to some aquatic species.

Vegetation management benefits some wildlife species and harms others. For example, lack of treatment or low disturbance tools favor mid-late successional habitats and associated wildlife; whereas early successional habitats and wildlife are favored by more intensive treatments. Alternative Modified G provides the greatest variety of habitats and associated species, because it uses the most balanced mix of low to moderate disturbance tools.

### Threatened and Endangered Species

Some species occur only in habitats where no vegetation management occurs. Low toxicities to animals, low risk of exposure, and use of biological evaluations limit risk of adverse herbicide effects on listed animals. Since threatened or endangered plants may be extremely sensitive to herbicides, mitigation measures and biological evaluations are essential for protecting these plants.



Lack of treatments may prevent recovery of species which require periodic disturbance. Many species are fire-dependent, and some are sensitive to intensive or frequent treatments. Alternatives E, G, and Modified G allow for full recovery and pose low risks to population viability due to their balanced mix of low to moderate disturbance tools.

### Vegetation

Lack of treatment or use of low disturbance tools favors woody species. High disturbance tools favor herbaceous species. Alternatives E, G, and Modified G use a mix of low to moderate disturbance tools which promote the greatest variety of species.

### Soil

Severe slash burns and raking pose high to extreme risks to soil productivity of all soils, mainly through loss of organic matter and nutrients. Moderate slash burns and piling pose low risks on poor soils. Soil compaction is only significant for raking on clay and loam soils. Erosion is most severe after heavy disking.

Lack of underburns in alternative A allows soil productivity in pine forests to deteriorate naturally through leaching and weathering, and increases occurrence and adverse effects of wildfires. Alternative C best protects soil productivity because only low disturbance tools are used and underburns prevent soil deterioration and wildfire effects.

### Water

No method significantly affects chemical water quality. Because herbicides are applied at low rates, are separated from streams and wells by buffers, and are subject to considerable downstream mixing and dilution, risks to water from typical application are very slight. Aerial herbicide application, however, increases risks of accidental pollution of streams.

In general, stormflows and sediment loads are increased slightly by low to moderate disturbance tools, and substantially by high disturbance tools like severe slash burns, raking, and heavy disking. Lack of underburns in Alternative A increases occurrence of severe wildfires. Alternative B best protects water quality because only low disturbance tools are used and underburns prevent some wildfire effects.

### Air

Emissions of pollutant gases are not sufficient to pose serious risks to air quality. Particulate emissions are least for grassland burns and grass underburns, moderate for slash burns and light brush underburns, and highest for wildfires. Long-term exclusion of underburns can cause available fuels to triple and greatly increase acres burned by wildfires.

Alternatives C, D, E, F, G, and Modified G emit comparable amounts of smoke. Alternative B emits the least because prescribed fire is restricted but still markedly reduces wildfire acres. Smoke emissions in Alternative A are highest due to greatly increased wildfires.

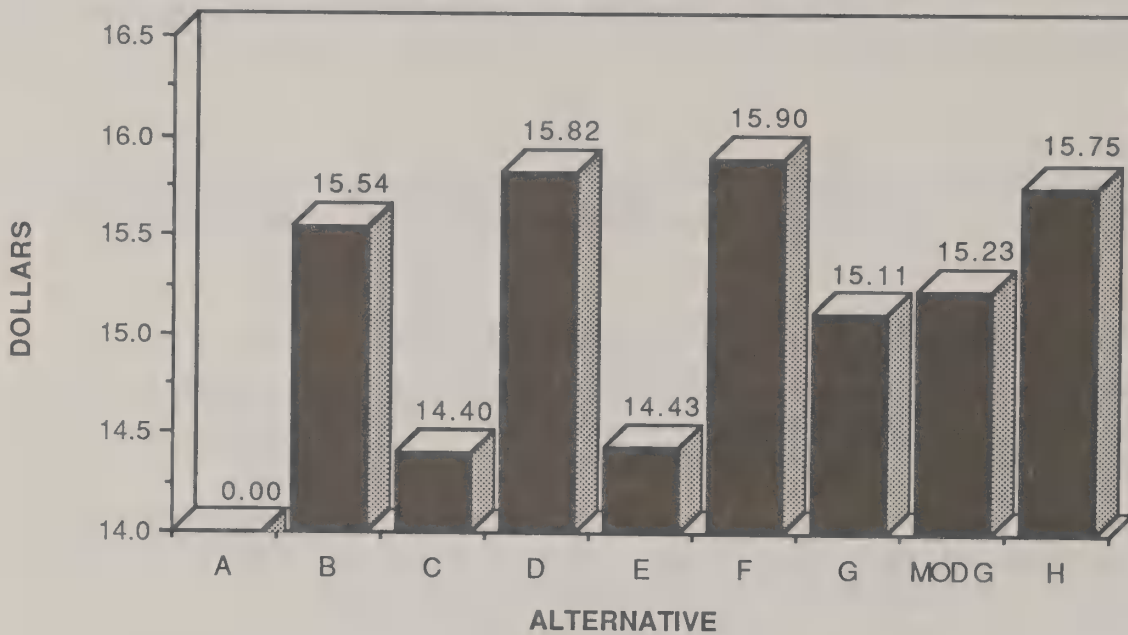
### Economics

Direct per-acre costs are lowest for prescribed fire. Indirect costs (sacrificed outputs) are generally reduced as market outputs increase. Lack of treatment reduces outputs and induces damages to facilities such as roads which deteriorate from lack of maintenance. Alternatives E, G, and Modified G have the greatest advantage because their direct costs are among the lowest and their indirect costs are low to moderate.

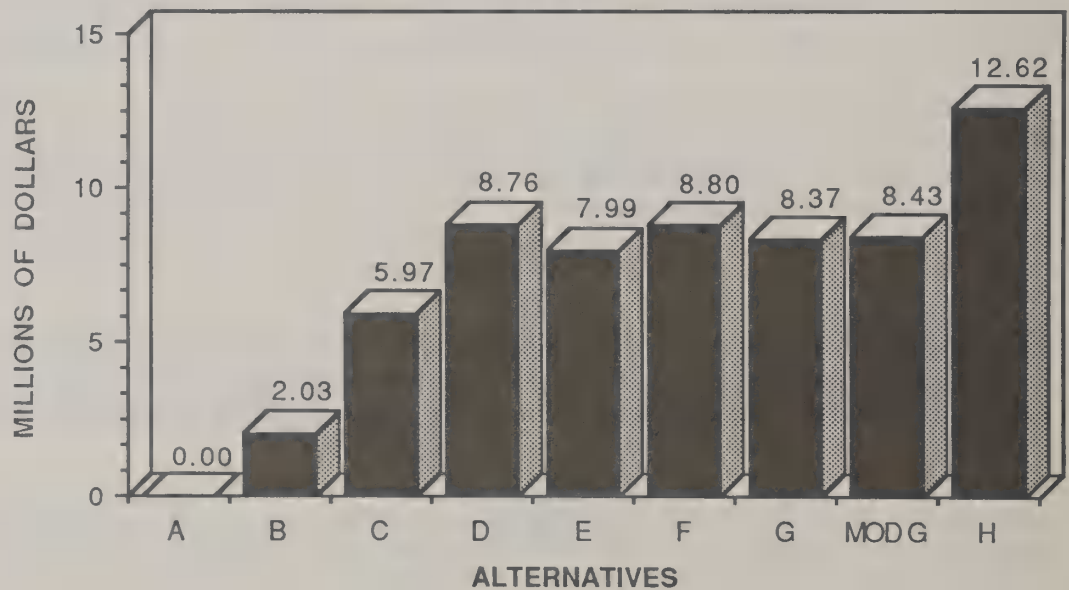
### Social Values

Public response becomes negative at the extremes of no treatment or high disturbance tools, and positive with manual methods. Visual values decline with high disturbance tools, but vistas are lost if treatments are excluded. Cultural resources are most damaged by soil-tilling tools like disking, ripping, and bedding. Alternatives E, G, and Modified G have the greatest advantage because public acceptance becomes positive and risks to visual values and cultural resources are moderate.

### PER ACRE TREATMENT COST



### TOTAL ANNUAL COST



## Aerial Application

Three alternatives, G, Modified G, and H, include aerial application of herbicides by helicopter. Projected treatments are 7,000 acres (less than .2 percent of the study area) for alternative G; 2,500 acres (about .06 percent of the study area) for alternative Modified G; and 28,000 acres (about .6 percent of the study area) for alternative H.



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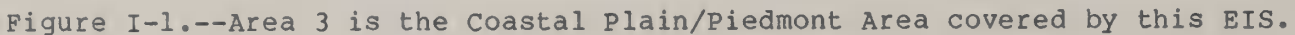
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# **Purpose and Need**

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1. APPALACHIAN MOUNTAINS
2. OZARK/OUACHITA MOUNTAINS
3. COASTAL PLAINS/PIEDMONT



This EIS follows the format recommended by the Council on Environmental Quality. Chapter I, Purpose and Need tells who, what, where, and why about the environmental analysis, and states the issues. Chapter II, Alternatives describes how alternatives were developed, explains which ones are considered, summarizes environmental effects, and identifies the preferred alternative. Chapter III, Affected Environment describes parts of the environment that would affect or be affected by the alternatives. This chapter does not describe effects (see chapter IV). Chapter IV, Environmental Consequences describes environmental impacts of alternatives, including the proposed action. Chapter V is a list of preparers and their experience and qualifications. Chapter VI shows consultations which were made and who received copies of the EIS. Chapter VII is a glossary of terms and acronyms. Chapter VIII lists reference materials. Chapter IX contains an index. Appendices contain specific information on topics too lengthy, technical, or detailed to be included in the text. Readers can quickly grasp important aspects of this EIS by reading the Summary beginning on page i in the preceding section.

I-i





## CHAPTER I

### PURPOSE AND NEED

#### IN BRIEF

Part A tells who prepared this environmental impact statement and what it is about. Part B tells why vegetation management is done. Parts C and D tell what decisions this document supports, how they relate to Forest Land and Resource Management Plans, and how they are implemented. Part E is an overview of the public involvement process. Part F contains a complete description of issues addressed. Part G describes some of the social aspects of herbicide use and briefly describes how and why the risk assessment was prepared.

#### A. INTRODUCTION

National Forests of the Southern Region are managed to provide a mix of goods and services to the public. Each Forest Land and Resources Management Plan details specific resource management objectives and output goals. These plans provide for access to the national forests, livestock grazing, timber management, visual quality, water quality, and vegetation, wildlife and fish diversity. To produce these outputs some vegetation management must be done. Different environmental conditions and different objectives and goals determine the need for and amount of vegetation management done.

##### 1. Area Analyzed

This environmental impact statement (EIS) prepared by the USDA Forest Service Southern Region discloses environmental effects of vegetation management on national forests and national grasslands of the Coastal Plain/Piedmont physiographic areas of the Southern Region (figure I-1 and table III-1). This EIS was guided by the National Environmental Policy Act of 1969 as amended, Council on Environmental Quality Regulations, and USDA Forest Service implementing procedures (FSM 1950).

##### 2. Activities Addressed

The vegetation management program covered by this EIS contains six activities. These activities are:

- Site preparation for reforestation of pines and hardwoods; which is done to reduce plant competition so that pine and hardwood seedlings and saplings get needed amounts of sunlight, water, nutrients, and growing space in order to survive and grow in newly established stands.



- Stand management for timber stand improvement (release, precommercial thinning); which maintains tree growth rates, species composition, adequate stocking, and stand conditions.

- Wildlife habitat improvement, including openings maintenance; which provides a wide variety of plants and habitat conditions beneficial to wildlife, and also protects and enhances habitats of threatened, endangered, proposed, and sensitive plant and animal species.

- Corridor maintenance for roads and trails, utilities, and railroads; which provides safe travelways and protects investments.

- Range forage improvement; which maintains plant species used by livestock.

- Fuels treatment; which is done to reduce hazardous fuels.

Activities affecting vegetation not addressed include silvicultural systems, harvest cutting methods, road construction, recreation and administrative site maintenance, and management of nurseries, seed orchards, and aquatic vegetation.

### **3. Methods Evaluated**

The EIS examines environmental effects of five vegetation management methods. These methods are:

- Herbicides, which can be applied as liquid or granules by hand, machine, or helicopter.

- Mechanical, the use of machines such as mowers or tractors and bulldozers with attachments.

- Prescribed fire, which can be applied by ground and aerial ignition tools.

- Manual, the use of hand-held tools.

- Biological, the use of livestock to control vegetation by grazing.

### **B. NEED FOR ACTION**

Vegetation management is the manipulation of plants to benefit a variety of forest resources and investments. It is needed to protect and improve forest growth, wildlife habitat, and range forage. It is required to maintain facilities such as roads, trails, and utility lines. It is essential to meet the special needs of some threatened, endangered, proposed, and sensitive species. Forest Land and Resource Management Plans call for many vegetation management activities. This EIS discloses environmental effects of those activities.

Four basic vegetation management strategies are available to meet the above needs. They are:

- Prevention means treating before damage occurs. Prevention activities usually intervene once in the natural processes of plant growth and succession to establish a temporary condition. Examples are site preparation and timber stand improvement.
- Maintenance means treating in repeated cycles. Maintenance activities intervene frequently in the natural processes of plant growth and succession to perpetuate a rather constant condition. Examples are wildlife habitat and range forage improvement, corridor maintenance, and fuels treatment.



- Correction means treating after damage occurs. Correction activities may be needed if prevention or maintenance was not done or not effective. Examples are restoring overgrown wildlife openings or failed regeneration areas.



• No action means no treatment. Natural processes are allowed to progress without human interference. No action is an option in most activities. For example, some sites do not require site preparation or timber stand improvement to achieve target stocking levels.

#### C. SCOPE OF DECISIONS

This EIS is used to make decisions about how the vegetation management program on national forests in the Coastal Plain/Piedmont is conducted. Major decisions are: (1) what methods and tools are allowed; (2) what intensity and frequency of treatments are used; and (3) what management requirements and mitigation measures are applied. The EIS provides analytical data that may be used when making site-specific decisions in the future.

#### D. IMPLEMENTING THE DECISION

Decisions based on this EIS are implemented in concert with Forest Land and Resource Management Plans. Plans set overall direction for managing national forests. The selected alternative from this EIS sets further direction on how vegetation is managed. Depending on which alternative is selected, Plans may need to be amended, especially regarding methods and tools allowed and mitigation measures (standards and guides) applied. Amendments to Plans will be done through the Record of Decision for this EIS.

Site-specific vegetation management projects are done within constraints set by the Plans and this EIS. Together, these two documents define the limits within which such projects may operate. Key components of project implementation include site analysis, project design, and monitoring.

##### 1. Site Analysis

Vegetation management projects must undergo site-specific environmental analysis in compliance with the National Environmental Policy Act (NEPA). Data on the site eligible for treatment is gathered and evaluated by trained personnel familiar with local environmental conditions and relationships. A detailed analysis of site conditions and environmental effects of alternative treatments is done. Information from this EIS and those done for Plans is used when applicable and valid. NEPA procedures ensure that information is available to public officials and citizens before decisions are made or actions are taken.

The analysis must evaluate direct, indirect, and cumulative environmental effects of vegetation management, considering the unique physical and biological characteristics of the site. It must evaluate a reasonable range of alternatives, including a "no action" alternative, which vary the mix of methods and intensity of tools used within the constraints set by this EIS and the Plans.

Effects to be evaluated include long-term soil productivity; water, air, and visual quality; vegetation; wildlife; fish; cultural resources; and effectiveness of treatments. A biological evaluation of potential effects on threatened, endangered, proposed, and sensitive species is also done.

## **2. Project Design**

Good design requires a thorough analysis. Project design depends on the effectiveness of treatments in meeting project objectives and on environmental effects they cause. Equally important are the constraints set by the alternative selected in the Record of Decision which follows this EIS. This alternative defines methods and tools that are allowed, intensity and frequency of treatments that must be used, and minimum mitigation measures that must be applied. Managers must work within these constraints to decide which vegetation management methods are best suited to the specific site conditions. Projects that are structured and timed to meet vegetation management objectives well and to pose minimal environmental risks are usually favored.

## **3. Monitoring**

Monitoring of environmental effects is done during and after treatment to assure that the project is implemented as designed and that mitigation measures are effective. Information gathered may be used to validate or refine treatments or to add further mitigation measures. A full array of treatments in diverse environmental conditions is monitored. Minor projects and those whose effects are already well documented may not be monitored.

Effects of treatments on vegetation, soil, wildlife, and threatened or endangered species are monitored in the treated area. Effects on water and aquatic life may be monitored onsite and downstream. Effects on air quality may be monitored onsite and downwind.

Monitoring during treatment is important if changes in tools or intensity are needed. Most monitoring is done just after treatment and at appropriate intervals thereafter. Monitoring is seldom needed beyond 3 years after project completion.

## **E. PUBLIC INVOLVEMENT**

A public involvement summary is in chapter VI. The Notice of Intent to prepare this EIS was published in the September 11, 1986 Federal Register. In January 1987 more than 11,000 interested individuals, groups, and agencies were asked to identify issues to be addressed in this EIS. Concurrently, a press release was distributed Regionwide. About 50 key contacts were also reached by phone or in person. Between January and September 1987, replies were received from 891 respondents. Analysis of this public

response identified 11 issues to be addressed. A revised Notice of Intent, based on early scoping results, was published in the May 5, 1987, Federal Register. This revision described methods which would be evaluated and estimated dates of availability of draft and final statements. Also, in May 1987, 6,000 information tabloids about issues and alternatives were distributed.

In May 1988, nearly 2,000 copies of the Draft EIS were mailed out for public comment. About 350 persons and organizations had responded by the end of August. Their comments were thoroughly analyzed. Many comments produced revisions to the EIS, most notably the development of a modified alternative G and the addition and revision of several mitigation measures (chapter II). Many editorial improvements were also suggested. The comments and our responses are in Volume III.

## **F. ISSUES ADDRESSED**

An issue is a subject or question of widespread public interest relating to management of a national forest or grassland. The following issues incorporate concerns expressed by the public, employees, and managers in the 891 responses we received in 1987.

### **1. Balance of Resources**

Commenters support balanced resource management and believe vegetation management is essential to achieve it. There is, however, widespread belief that vegetation management on treated sites will favor timber production at the expense of wildlife, recreation, ecosystem diversity, soil and water, aesthetics, and cultural resources.

### **2. Timing, Frequency and Intensity of Prescribed Fire**

Commenters prefer prescribed fire over other methods of vegetation management. They view it as a natural process which benefits wildlife and fire-dependent plant communities, is safe and economical, and reduces wildfire hazards. They express mild concern about potential adverse effects on soil, water, and air quality. Season (growing or dormant), intensity, and frequency of burns should be managed to increase benefits and reduce adverse effects. Most people believe the Forest Service has the expertise to use this method effectively.

### **3. Concern for Human Health and Safety**

Most respondents see mechanical, hand, and prescribed fire methods as relatively safe, though they are concerned about effects of burning after herbicide treatment and highway hazards from smoke. These people see herbicides as a potential threat to the health of the public, including herbicide applicators and forest users who visit treated areas. Many people believe that proper training and supervision of herbicide applicators can reduce health risks. Some people want health and safety risks assessed for all methods so that overall risks can be minimized.



#### **4. Reduced Plant and Animal Diversity**

Respondents generally see effects of vegetation management on plant and animal diversity as negative. Moreover, they see combinations of herbicides and mechanical methods as very undesirable. These commenters feel that such combinations completely remove some species from a site. Prescribed fire and hand methods are viewed as more desirable, because they are considered more "natural" and are thought to suppress vegetation temporarily. Concerns about diversity are often linked with concerns about wildlife habitat.

#### **5. Inadequate Communication--Lack of Understanding**

Commenters feel the Forest Service poorly communicates the reasons why vegetation management is done and why certain methods and techniques are chosen. Respondents say that they do not understand Forest Service definitions of desirable species, environmental effects, and safety precautions. This perceived lack of communication by the Forest Service creates negative attitudes about herbicides because of suspected but unproven impacts. If they were better informed about effects and planned treatments, many people would support a broader selection of vegetation management tools.

#### **6. Cost Comparison Between Methods**

Commenters support vegetation management methods which achieve our objectives with least cost and least environmental impact. These people prefer prescribed fire because they believe it offers multiple benefits at small cost. Herbicides are the next most economical method. These commenters also see mechanical methods as costly and providing little employment. Although costs of hand treatments are high, some people prefer them because such treatments provide the most employment and cause the least environmental impact.

#### **7. Loss of Long-Term Soil Productivity**

Commenters see herbicides, mechanical methods, and prescribed fire as harmful to soil productivity. Their concerns focus on erosion, compaction, rutting, loss of soil micro-organisms, and long-term impact on site productivity.

#### **8. Diminished Surface and Ground Water Quality**

Those people responding feel that herbicides are most harmful to drinking water and aquatic communities. The activity, breakdown, and persistence of herbicides in aquatic systems are not well defined scientifically. Pollution of water sources by herbicides is a major concern. Mechanical methods and prescribed fire are considered to have negative effects on water quality. Many believe that if methods are chosen to fit site conditions and proper protection is provided, risks to water quality can be held to acceptable levels.

**9. Known and Unknown Effects of Herbicides**

There are deep, widespread concerns about potential short- and long-term adverse effects of herbicides on the environment and human health. These concerns are intensified by lack of knowledge about herbicides and lack of trust in study results. There is reluctant willingness to accept herbicide use, provided that stringent safeguards and monitoring are assured. Some people are concerned about effects of specific herbicides and application techniques on non-target organisms.

**10. Aerial Application of Herbicides**

Public concern has resulted in suspension of aerial application of herbicides. Risks to forest users, adjacent landowners, forest workers, and the environment must be evaluated to determine which herbicides may be applied safely, where in the environment they may be applied, and what conditions are necessary to minimize risk.

**11. Benefits to Wildlife Habitat**

Commenters are deeply concerned about wildlife values and strongly support actions which benefit wildlife (game, non-game, and threatened and endangered) species. Herbicides are seen as harmful to wildlife because of suspected direct physical effects, genetic damage, food chain effects, and long-term habitat changes. On the other hand, prescribed fire and hand methods are seen as benefiting wildlife. Some people are concerned that threatened and endangered species or habitat will unknowingly be destroyed regardless of method used.

These issues were used in the formulation, evaluation, and selection of alternatives (chapter II). The effects of the alternatives on issues are identified and these effects are considered when choosing the preferred alternative.

**12. Unrelated Comments**

Several comments were received on a wide range of topics beyond the scope of this EIS. These comments, though meaningful, are not incorporated in the issue statements. Some categories of comments which won't be addressed are silvicultural systems, harvest cutting methods, off-road vehicles, littering, road construction, wilderness designation, military uses, minerals, forest signs, landscape-wide diversity, illegal activities, southern pine beetle, beavers, or multiple-use in a general landscape-wide sense.

Most of these are considered unrelated issues because they have been analyzed and addressed in Forest Land and Resource Management Plans. For example, each Plan discusses which silvicultural system and associated harvest cutting methods are appropriate, and where they are to be used, based on each forest's unique mixture of forest resources and public needs. This EIS does not reanalyze those issues, but does evaluate vegetation management methods for the activities listed in section A of this chapter.

## G. ABOUT HERBICIDES

This EIS analyzes five methods of vegetation management, but herbicide use is a focal point of controversy. Issues about herbicides are both scientific and emotional. The public seems to distrust those forest managers who use herbicides. The respondents to our inquiry expressed fear of adverse health effects, including cancer. And, indeed, there is some scientific uncertainty about long-term effects of many herbicides. People commonly ask questions like, "Do these herbicides cause cancer or birth defects?" "What are the short-term and long-term effects of exposure to herbicides?" and "How do they affect wildlife and other aspects of the environment?"

These questions are discussed in the risk assessment in appendix A. It documents an exhaustive study of the most up-to-date data on herbicides (and materials mixed with them for application) proposed for use in the Southern Region. This risk assessment presents information on toxicity for each herbicide, evaluates the possibilities for humans or other animals to be exposed to the herbicides, and then estimates the risk of harmful effects for those toxic properties and exposures. The estimates of risk take into account scientific uncertainty and account for differences in individual sensitivities by incorporating safety factors. The risk assessment discloses the modeling process used to estimate risk.

Discussion of herbicide effects in chapter IV and mitigation measures for herbicides in chapter II are based on the scientific findings of the risk assessment.

The use of trade, firm, or corporation names in this EIS is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U. S. Department of Agriculture or the Forest Service of any product or service to the exclusion of others that may be suitable.





# Alternatives

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## CHAPTER II

## 2. Guidelines for Developing Alternatives

Each alternative conforms to the following guidelines:

1. Considers the goals, objectives, and decisions of Forest Land and Resource Management Plans;
2. Should not be constrained by funding;
3. Responds to issues (Chapter I);
4. Should be implementable by the Forest Service;
5. Conforms to Federal laws and regulations (unless the alternative contemplates a specific change in laws or regulations).

## B. ALTERNATIVES CONSIDERED IN DETAIL

This section describes the amount and nature of vegetation management done in each alternative. First, the underlying theme of the alternative is stated. Second, the methods and tools allowed in the alternative are described. Third, based on field data, the average frequency of activities that recur every few years (fuel reduction, wildlife and range habitat improvement, corridor maintenance) is projected. Frequencies are not shown for site preparation and timber stand improvement because they usually occur once per stand rotation, not on established cycles. Finally, average number of acres treated per year by each method are estimated. These acres are only projections used to evaluate environmental effects quantitatively. They were derived by professionals familiar with vegetation management activities and environmental conditions in the field. They are displayed for all Coastal Plain/Piedmont forests and grasslands, not for individual units. Upon implementation, the actual program may vary from these projections.

### 1. Alternative A (No Action)

Theme	In this "no action" alternative, vegetation management is not done. Existing vegetation is allowed to grow without manipulation.
Methods and Tools	No treatments of any kind are allowed.
Average Frequency	None.

#### Estimated Program

<u>Method</u>	<u>Projected Acres/Yr</u>	<u>Percent Total Acres Treated</u>
Fire	0	0
Herbicides	0	0
Manual	0	0
Mechanical	0	0
Biological	<u>0</u>	<u>0</u>
	0	0



## 2. Alternative B

### Theme

Vegetation management is done only to protect public health and safety and forest and grassland resources. Activities are limited to hazardous fuel reduction, corridor maintenance, and protection of habitat for threatened and endangered (T&E) species. Acres treated per year total 2.8 percent of National Forest System lands in the Coastal Plain/Piedmont.

Hazardous fuel treatment occurs only when wildfire threat is imminent in high risk areas. Corridor maintenance occurs only when vegetation impairs safety or investments on trails, roads, and utility lines. Habitat management for T&E species maintains current populations but does not assure population recovery.

Number of acres treated and intensity and frequency of treatments are sharply reduced from present levels to lessen potential adverse effects on human health and safety, non-target plants and animals, soil, and water. The present mix of methods is applied, however.

Additional mitigation measures beyond those presently required are applied. All mitigations listed in section II.E apply except 1.b.(6,7,8,9), 2.b.(3,6,7,8), and 2.c.(25).

### Methods and Tools

Herbicides: Herbicides with least health and environmental risks (table II-1) are applied by hand (backpack sprayer, spotgun, hypo-hatchet, injector, axe/sprayer) only. The major use is roadside maintenance. Selective treatments only are allowed in T&E habitat. Broadcast treatments are allowed only in roadside and utility line maintenance, and then only when site conditions require them.

Mechanical: Only low disturbance tools are allowed. Since activities are so limited, only mowing is appropriate. The major use is roadside maintenance.

Prescribed Fire: Only low intensity burns with timing and location restricted are applied by ground and aerial ignition tools. Growing season burns are allowed only if needed to maintain T&E species. The major use is hazardous fuel reduction.

Manual: Hand (axe, blade, clipper) and power tools (chain saw, brush cutter) are allowed. Major uses are roadside and trail maintenance.

Biological: This method is not used.

Projected Average Treatment Frequency	Area Treated	Intervals (Years)
	T&E habitat; County/State roads; Railroads	3
	Gas lines	4
	Hazardous fuels (Coastal Plain); Trails	5
	Hazardous fuels (Piedmont)	7
	FS roads	8
	Power lines	10

Estimated Program	Method	Projected Acres/Yr	Percent Total Acres Treated
	Herbicides	3,379	2.6
	Mechanical	12,332	9.5
	Fire	113,573	87.2
	Manual	956	0.7
	Biological	0	0
		130,240	100.0

Projected acres/year by method by program:

Method					
Program	Herbicides	Mech.	Fire	Manual	Biol.
Projected acres/year	3,379	12,332	113,573	956	0
Fuels treatment	0	0	105,375	0	0
T&E species habitat	84	84	8,178	85	0
Other wildlife habitat	0	0	0	0	0
Range habitat	0	0	0	0	0
Trails	0	63	0	190	0
Roads-Forest Service	1,280	4,479	0	640	0
Roads-Co/State	1,533	6,134	0	0	0
Power lines	223	728	0	19	0
Railroads	0	0	20	0	0
Gas lines	259	844	0	22	0
Site preparation	0	0	0	0	0
Timber stand improvement*	0	0	0	0	0

\*--Includes release, precommercial thinning, understory species treatments.

Percent of herbicides applied using selective versus broadcast techniques:

Program	Percent Selective	Percent Broadcast
T&E species habitat	100	0
Roads-Forest Service	20	80
Roads-Co/State	10	90
Utility (power/gas) lines	30	70

### 3. Alternative C

#### Theme

Vegetation management is restricted to treatments that achieve minimum resource objectives. Number of acres treated and intensity and frequency of treatments are reduced from present levels to lessen potential adverse effects on human health and safety, non-target plants and animals, soil, and water. Acres treated per year total 9.0 percent of National Forest System lands in the Coastal Plain/Piedmont.

Hazardous fuel treatment occurs only when fuel buildup nears dangerous levels. Wildlife and range treatments occur to promote recovery of threatened and endangered (T&E) species and when habitat conditions seriously limit populations. Corridors are maintained when vegetation threatens safety or investments on trails, roads, and utility lines. Site preparation and timber stand improvement are done only if needed to achieve minimum stocking.

Substantial shifts from present mix of methods occur in power line maintenance (from use of mechanical methods to herbicides and manual methods), trail maintenance and precommercial thinning (from use of mechanical to manual methods), and pine release (from use of herbicides and prescribed fire to manual methods).

Additional mitigation measures beyond those presently required are applied. All mitigations listed in section II.E apply except 2.b.(6,7,8) and 2.c.(25).

#### Methods and Tools

Herbicides: Herbicides with least health and environmental risks (table II-1) are applied by hand (backpack sprayer, spotgun, hypo-hatchet, injector, axe/sprayer) only. Major uses are site preparation and roadside maintenance. Selective treatments only are allowed in wildlife habitat improvement. Broadcast treatments are allowed only in site preparation and release, roadside and utility line maintenance, and range forage improvement, and then only when site conditions require them.

Mechanical: Only low disturbance tools (mowing, chopping, shearing, ripping, scarifying) are allowed. Major uses are site preparation and roadside maintenance.

Prescribed Fire: Only low intensity burns with timing and location restricted are applied by ground and aerial ignition tools. Major uses are hazardous fuel reduction, wildlife habitat improvement, and range forage improvement.



Manual: Hand (axe, blade, clipper) and power tools (chain saw, brush cutter) are allowed. Major uses are wildlife habitat improvement, site preparation, and roadside and trail maintenance.

Biological: Livestock grazing is allowed for vegetation management only in pine release.

Projected Average Treatment Frequency	Area Treated	Intervals (Years)
	T&E habitat; County/State roads; Railroads	2
	Trails; Gas lines	3
	FS roads	4
	Range habitat	5
	Hazardous fuels; Other wildlife habitat - Coastal Plain	5
	Hazardous fuels; Other wildlife habitat - Piedmont	7
	Power lines	8

Estimated Program	Method	Projected Acres/Yr	Percent Total Acres Treated
	Herbicides	17,117	4.1
	Mechanical	35,458	8.6
	Fire	354,934	85.8
	Manual	6,299	1.5
	Biological	16	0.0
		413,824	100.0

Projected acres/year by method by program:

Method					
Program	Herbicides	Mech.	Fire	Manual	Biol.
Projected acres/year	17,117	35,458	354,934	6,299	16
Fuels treatment	0	0	167,298	0	0
T&E species habitat	406	406	39,380	406	0
Other wildlife habitat	994	1,138	96,583	1,989	0
Range habitat	788	788	37,836	0	0
Trails	0	0	0	421	0
Roads-Forest Service	1,706	5,973	0	853	0
Roads-Co/State	2,300	9,200	0	0	0
Power lines	545	545	0	122	0
Railroads	0	0	30	0	0
Gas lines	345	1,125	0	30	0
Site preparation	8,862	15,951	8,862	1,772	0
Timber stand improvement*	1,171	332	4,945	706	16

\*--Includes release, precommercial thinning, understory species treatments.

Percent of herbicides applied using selective versus broadcast techniques:

<u>Program</u>	<u>Percent Selective</u>	<u>Percent Broadcast</u>
Wildlife (incl. T&E) habitat	100	0
Range habitat	80	20
Roads-Forest Service	20	80
Roads-Co/State	10	90
Utility (power/gas) lines	30	70
Site preparation	70	30
Timber stand improvement	70	30

#### 4. Alternative D

Theme

Herbicides are not allowed. Number of acres treated and frequency of treatments are at present levels, but intensity of treatments is reduced to lessen potential adverse effects on human health and safety, non-target plants and animals, soil, and water. Acres treated per year total 12.0 percent of National Forest System lands in the Coastal Plain/Piedmont.

The largest shifts from use of herbicides occur in site preparation (mostly to prescribed fire and mechanical methods), roadside maintenance (to mechanical and manual methods) and pine release (nearly all to manual methods).

Use of prescribed fire increases only in site preparation. Use of mechanical methods increases most in site preparation and roadside maintenance. Use of manual methods increases most in timber stand improvement, wildlife habitat improvement, and roadside maintenance.

Additional mitigation measures beyond those presently required are applied. All mitigations listed in section II.E apply except for herbicides (the 2.c group).

Methods and Tools

Herbicides: Herbicide use is not allowed.

Mechanical: Only low to moderate disturbance tools (mowing, chopping, shearing, ripping, scarifying, piling, bedding, light disking) are allowed. Major uses are roadside maintenance and site preparation.

Prescribed Fire: Only low to moderate intensity burns are applied by ground and aerial ignition tools. Major uses are hazardous fuel reduction, wildlife habitat improvement, and range forage improvement.

Manual: Hand (axe, blade, clipper) and power tools (chain saw, brush cutter) are allowed. Major uses are timber stand improvement, trail and roadside maintenance, and wildlife habitat improvement.

Biological: Livestock grazing is allowed for vegetation management only in pine release.

Projected Average Treatment Frequency	Area Treated	Intervals (Years)
	Trails; County/State roads; Railroads	1
	T&E habitat; Gas lines	2
	Range habitat; FS roads	3
	Hazardous fuels; Other wildlife habitat - Coastal plain	4
	Hazardous fuels; Other wildlife habitat - Piedmont	6
	Power lines	6

Estimated Program	Method	Projected Acres/Yr	Percent Total Acres Treated
	Herbicides	0	0
	Mechanical	71,097	12.8
	Fire	464,284	83.9
	Manual	18,042	3.3
	Biological	53	0.0
		553,476	100.0

Projected acres/year by method by program:

Method					
Program	Herbicides	Mech.	Fire	Manual	Biol.
Projected acres/year	0	71,097	464,284	18,042	53
Fuels treatment	0	0	208,281	0	0
T&E species habitat	0	406	39,380	812	0
Other wildlife habitat	0	1,239	119,922	3,708	0
Range habitat	0	2,627	63,059	0	0
Trails	0	316	0	947	0
Roads-Forest Service	0	10,878	0	1,920	0
Roads-Co/State	0	20,700	0	2,300	0
Power lines	0	1,454	0	162	0
Railroads	0	0	60	0	0
Gas lines	0	2,025	0	225	0
Site preparation	0	29,955	17,474	2,496	0
Timber stand improvement*	0	1,497	16,108	5,472	53

\*--Includes release, precommercial thinning, understory species treatments.



5. Alternative E

Theme                                    Use of manual methods and prescribed fire increases, and use of mechanical methods and herbicides decreases, from present levels. Number of acres treated and frequency of treatments are at present levels, but intensity of treatments is reduced to lessen potential adverse effects on human health and safety, non-target plants and animals, soil, and water. Acres treated per year total 12.0 percent of National Forest System lands in the Coastal Plain/Piedmont.

The largest shifts among methods occur in site preparation (from use of mechanical methods and herbicides to manual methods and prescribed fire), wildlife habitat improvement (from use of prescribed fire, herbicides, and mechanical methods to manual methods), and pine release and roadside maintenance (from use of herbicides to manual methods).

Use of manual methods increases most in site preparation, timber stand improvement, and wildlife habitat improvement. Use of prescribed fire increases only in site preparation. Use of mechanical methods is eliminated in range forage improvement and trail maintenance and sharply reduced in site preparation. Use of herbicides is eliminated in wildlife habitat improvement and sharply reduced in site preparation, pine release, and roadside maintenance.

Additional mitigation measures beyond those presently required are applied. All mitigations listed in section II.E apply except 2.c.(25).

Methods and Tools                    Herbicides: Herbicides with least health and environmental risks (table II-1) are applied by hand (backpack sprayer, spotgun, hypo-hatchet, injector, axe/sprayer) and machine (boom sprayer, granular spreader). Major uses are site preparation and roadside maintenance. Broadcast treatments are allowed only when required by site conditions.

Mechanical: Only low to moderate disturbance tools (mowing, chopping, shearing, ripping, scarifying, piling, bedding, light disking) are allowed. Major uses are roadside maintenance and site preparation.

Prescribed Fire: Only low to moderate intensity burns are applied by ground and aerial ignition tools. Major uses are hazardous fuel reduction, wildlife habitat improvement, and range forage improvement.

Manual: Hand (axe, blade, clipper) and power tools (chain saw, brush cutter) are allowed. Major uses are site preparation, roadside and trail maintenance, and timber stand improvement.

Biological: Livestock grazing is allowed for vegetation management only in pine release.

Projected Average Treatment Frequency	Area Treated	Intervals (Years)
	Trails; County/State roads; Railroads	1
	T&E habitat; Gas lines	2
	Range habitat; FS roads	3
	Hazardous fuels; Other wildlife habitat - Coastal Plain	4
	Hazardous fuels; Other wildlife habitat - Piedmont	6
	Power lines	6

Estimated Program	Method	Projected Acres/Yr	Percent Total Acres Treated
	Herbicides	11,328	2.0
	Mechanical	35,916	6.5
	Fire	472,529	85.4
	Manual	33,650	6.1
	Biological	53	0.0
		553,476	100.0

Projected acres/year by method by program:

Method					
Program	Herbicides	Mech.	Fire	Manual	Biol.
Projected acres/year	11,328	35,916	472,529	33,650	53
Fuels treatment	0	0	208,281	0	0
T&E species habitat	0	0	39,380	1,218	0
Other wildlife habitat	0	1,138	120,023	3,708	0
Range habitat	657	0	63,715	1,314	0
Trails	0	0	0	1,263	0
Roads-Forest Service	1,280	8,958	0	2,560	0
Roads-Co/State	2,300	18,400	0	2,300	0
Power lines	727	727	0	162	0
Railroads	0	0	60	0	0
Gas lines	900	900	0	450	0
Site preparation	4,992	4,993	24,962	14,978	0
Timber stand improvement*	472	800	16,108	5,697	53

\*--Includes release, precommercial thinning, understory species treatments.

Percent of herbicides applied using selective versus broadcast techniques:

Program	Percent Selective	Percent Broadcast
Range habitat	80	20
Roads-Forest Service	20	80
Roads-Co/State	10	90
Utility (power/gas) lines	30	70
Site preparation	70	30
Timber stand improvement	70	30

6. Alternative F

Theme	<p>The mix of methods, number of acres treated, and intensity and frequency of treatments presently specified in Forest Land and Resource Management Plans are applied. Acres treated per year total 12.0 percent of National Forest System lands in the Coastal Plain/Piedmont.</p> <p>Hazardous fuels are treated only by prescribed fire. Wildlife habitat and range forage improvement are done almost totally by prescribed fire. Corridors are maintained mostly by mechanical methods and herbicides. Site preparation is done almost totally by mechanical methods, prescribed fire, and herbicides. Timber stand improvement is done mostly by prescribed fire and herbicides.</p> <p>Only mitigation measures presently required apply. All those listed in section II.E apply except 1.h.(20,22), 2.a.(3,4,5,14), and 2.c.(3,4,5,6,13,14,17,18,25).</p>		
Methods and Tools	<p><u>Herbicides:</u> Herbicides are applied by hand (backpack sprayer, spotgun, hypo-hatchet, injector, axe/sprayer) and machine (boom sprayer, granular spreader). Major uses are site preparation, roadside maintenance, and pine release.</p> <p><u>Mechanical:</u> Low to high disturbance tools (mowing, chopping, shearing, ripping, scarifying, piling, bedding, light and heavy disking, raking) are allowed. Major uses are roadside maintenance and site preparation.</p> <p><u>Prescribed Fire:</u> Low to high intensity burns are applied by ground and aerial ignition tools. Major uses are hazardous fuel reduction, wildlife habitat improvement, and range forage improvement.</p> <p><u>Manual:</u> Hand (axe, blade, clipper) and power tools (chain saw, brush cutter) are allowed. Major uses are roadside and trail maintenance and timber stand improvement.</p> <p><u>Biological:</u> This method is not used.</p>		
Projected Average Treatment Frequency	<u>Area Treated</u>	<u>Intervals (Years)</u>	
	Trails; County/State roads; Railroads	1	
	T&E habitat; Gas lines	2	
	Range habitat; FS roads	3	
	Hazardous fuels; Other wildlife habitat - Coastal Plain	4	
	Hazardous fuels; Other wildlife habitat - Piedmont	6	
	Power lines	6	



Estimated Program	Method	Projected Acres/Yr	Percent Total Acres Treated
	Herbicides	26,793	4.9
	Mechanical	59,231	10.7
	Fire	463,076	83.6
	Manual	4,376	0.8
	Biological	0	0
		553,476	100.0

Projected acres/year by method by program:

Method					
Program	Herbicides	Mech.	Fire	Manual	Biol.
Projected acres/year	26,793	59,231	463,076	4,376	0
Fuels treatment	0	0	208,281	0	0
T&E species habitat	406	406	39,380	406	0
Other wildlife habitat	1,236	1,239	122,394	0	0
Range habitat	657	657	64,372	0	0
Trails	0	316	0	947	0
Roads-Forest Service	2,560	8,958	0	1,280	0
Roads-Co/State	4,600	18,400	0	0	0
Power lines	372	1,212	0	32	0
Railroads	0	0	60	0	0
Gas lines	517	1,688	0	45	0
Site preparation	11,982	24,963	12,481	499	0
Timber stand improvement*	4,463	1,392	16,108	1,167	0

\*--Includes release, precommercial thinning, understory species treatments.

Percent of herbicides applied using selective versus broadcast techniques:

Program	Percent Selective	Percent Broadcast
Wildlife (incl. T&E) habitat	100	0
Range habitat	80	20
Roads-Forest Service	20	80
Roads-Co/State	10	90
Utility (power/gas) lines	30	70
Site preparation	70	30
Timber stand improvement	70	30

## 7. Alternative G

Theme

Use of herbicides and prescribed fire increases, and use of mechanical methods decreases, from present levels. Number of acres treated and frequency of treatments are at present levels, but intensity of treatments is reduced to lessen potential adverse effects on human health and safety,

non-target plants and animals, soil, and water. Acres treated per year total 12.0 percent of National Forest System lands in the Coastal Plain/Piedmont.

The largest shifts among methods occur in roadside and utility line maintenance (from use of mechanical and manual methods to herbicides) and site preparation (from use of mechanical methods to prescribed fire and herbicides).

Use of herbicides increases most in roadside maintenance and site preparation. Use of prescribed fire increases only in site preparation. Use of mechanical methods decreases mostly in roadside maintenance and site preparation. Use of manual methods changes little.

Aerial application of herbicides is allowed for some site preparation and utility line maintenance.

Additional mitigation measures beyond those presently required are applied. All mitigations listed in section II.E apply.

#### Methods and Tools

Herbicides: Herbicides with least health and environmental risks (table II-1) are applied by hand (backpack sprayer, spotgun, hypo-hatchet, injector, axe/sprayer), machine (boom sprayer, granular spreader), and air (helicopter only). Major uses are roadside maintenance, site preparation, and pine release. Selective treatments only are allowed in wildlife habitat improvement and trail maintenance. Broadcast treatments are allowed only in range forage improvement, roadside and utility line maintenance, site preparation, and timber stand improvement, and then only when site conditions require them. Aerial application is allowed only in site preparation and utility line maintenance where rugged terrain or dense growth makes other methods less practical.

Mechanical: Only low to moderate disturbance tools (mowing, chopping, shearing, ripping, scarifying, piling, bedding, light disking) are allowed. Major uses are site preparation and roadside maintenance.

Prescribed Fire: Only low to moderate intensity burns are applied by ground and aerial ignition tools. Major uses are hazardous fuel reduction, wildlife habitat improvement, and range forage improvement.

Manual: Hand (axe, blade, clipper) and power tools (chain saw, brush cutter) are allowed. Major uses are trail and roadside maintenance, wildlife habitat improvement, and precommercial thinning.

Biological: Livestock grazing is allowed for vegetation management only in pine release.

Projected Average Treatment Frequency	Area Treated	Intervals (Years)
	Trails; County/State roads; Railroads	1
	T&E habitat; Gas lines	2
	Range habitat; FS roads	3
	Hazardous fuels; Other wildlife habitat - Coastal plain	4
	Hazardous fuels; Other wildlife habitat - Piedmont	6
	Power lines	6

Estimated Program	Method	Projected Acres/Yr	Percent Total Acres Treated
	Herbicides (ground)	42,312	7.6
	Herbicides (aerial)	7,000	1.3
	Mechanical	32,247	5.8
	Fire	467,038	84.4
	Manual	4,823	0.9
	Biological	53	0.0
		553,476	100.0

Projected acres/year by method by program:

Program	Method		Mech.	Fire	Manual	Biol.
	Herbicides					
	Ground	Aerial				
Projected acres/year	42,315	7,000	32,247	467,038	4,823	53
Fuels treatment	0	0	0	208,281	0	0
T&E species habitat	406	0	406	39,380	406	0
Other wildlife habitat	2,472	0	1,138	120,023	1,236	0
Range habitat	1,314	0	657	63,715	0	0
Trails	90	0	36	0	1,137	0
Roads-Forest Service	7,717	0	4,441	0	640	0
Roads-Co/State	15,019	0	7,981	0	0	0
Power lines	336	1,000	280	0	0	0
Railroads	0	0	0	60	0	0
Gas lines	274	1,000	976	0	0	0
Site preparation	9,963	5,000	14,992	19,471	499	0
Timber stand improvement*	4,724	0	1,340	16,108	905	53

\*--Includes release, precommercial thinning, understory species treatments.



Percent of herbicides applied using selective versus broadcast techniques:

<u>Program</u>	<u>Ground Applications</u>		<u>Aerial Application</u>	
	<u>% Selective</u>	<u>% Broadcast</u>	<u>% Selective</u>	<u>% Broadcast</u>
Wildlife (incl. T&E) habitat	100	0	0	0
Range habitat	80	20	0	0
Trails	100	0	0	0
Roads-Forest Service	20	80	0	0
Roads-Co/State	10	90	0	0
Utility (power/gas) lines	30	70	0	100
Site preparation	70	30	0	100
Timber stand improvement	70	30	0	0

## 8. Alternative Modified G

### Theme

This alternative was developed in response to public comment about the Draft EIS. It is a modification of alternative G. As described in detail here and displayed for comparison purposes in tables II-3 through II-9, its actions and effects fall within the range of those disclosed for the other alternatives in the Draft EIS.

Use of herbicides and prescribed fire increases, and use of mechanical methods decreases, from present levels, but the shift is less than in alternative G. Number of acres treated and frequency of treatments are at present levels, but intensity of treatments is reduced to lessen potential adverse effects on human health and safety, non-target plants and animals, soil, and water. Acres treated per year total 12.0 percent of National Forest System lands in the Coastal Plain/Piedmont.

The largest shifts among methods occur in roadside and utility line maintenance (from use of mechanical methods to herbicides) and site preparation (from use of mechanical methods to prescribed fire and herbicides).

Use of herbicides increases most in roadside maintenance and site preparation. Use of prescribed fire increases only in site preparation. Use of mechanical methods decreases mostly in site preparation and roadside maintenance. Use of manual methods changes little.

Aerial application of herbicides is allowed for less site preparation and utility line maintenance than in alternative G.

Additional mitigation measures beyond those presently required are applied. All mitigations listed in section II.E apply.

## Methods and Tools

Herbicides: Herbicides with least health and environmental risks (table II-1) are applied by hand (backpack sprayer, spotgun, hypo-hatchet, injector, axe/sprayer), machine (boom sprayer, granular spreader), and air (helicopter only). Major uses are site preparation, roadside maintenance, and pine release. Selective treatments only are allowed in wildlife habitat improvement and trail maintenance. Broadcast treatments are allowed only in range forage improvement, roadside and utility line maintenance, site preparation, and timber stand improvement, and then only when site conditions require them. More herbicide is applied selectively in roadside and utility line maintenance, site preparation, and timber stand improvement than in the other alternatives. Aerial application is allowed only in site preparation and utility line maintenance where rugged terrain or dense growth makes other methods impractical.

Mechanical: Only low to moderate disturbance tools (mowing, chopping, shearing, ripping, scarifying, piling, bedding, light disking) are allowed. Major uses are site preparation and roadside maintenance.

Prescribed Fire: Only low to moderate intensity burns are applied by ground and aerial ignition tools. Major uses are hazardous fuel reduction, wildlife habitat improvement, and range forage improvement.

Manual: Hand (axe, blade, clipper) and power tools (chain saw, brush cutter) are allowed. Major uses are trail and roadside maintenance, wildlife habitat improvement, and precommercial thinning.

Biological: This method is not used.

Projected Average Treatment Frequency	Area Treated	Intervals (Years)
	Trails; County/State roads; Railroads	1
	T&E habitat; Gas lines	2
	Range habitat; FS roads	3
	Hazardous fuels; Other wildlife habitat - Coastal Plain	4
	Hazardous fuels; Other wildlife habitat - Piedmont	6
	Power lines	6

Estimated Program	Method	Projected Acres/Yr	Percent Total Acres Treated
	Herbicides (ground)	37,029	6.7
	Herbicides (aerial)	2,500	0.4
	Mechanical	41,582	7.5
	Fire	467,038	84.4
	Manual	5,327	1.0
	Biological	0	0
		553,476	100.0

Projected acres/year by method by program:

Program	Method		Mech.	Fire	Manual	Biol.
	Herbicides					
	Ground	Aerial				
Projected acres/year	37,029	2,500	41,582	467,038	5,327	0
Fuels treatment	0	0	0	208,281	0	0
T&E species habitat	406	0	406	39,380	406	0
Other wildlife habitat	2,472	0	1,138	120,023	1,236	0
Range habitat	1,314	0	657	63,715	0	0
Trails	90	0	36	0	1,137	0
Roads-Forest Service	4,479	0	7,679	0	640	0
Roads-Co/State	9,200	0	13,800	0	0	0
Power lines	408	400	776	0	32	0
Railroads	0	0	0	60	0	0
Gas lines	525	600	1,080	0	45	0
Site preparation	13,463	1,500	14,992	19,471	499	0
Timber stand improvement*	4,672	0	1,018	16,108	1,332	0

\*--Includes release, precommercial thinning, understory species treatments.

Percent of herbicides applied using selective versus broadcast techniques:

Program	Ground Applications		Aerial Application	
	% Selective	% Broadcast	% Selective	% Broadcast
Wildlife (incl. T&E) habitat	100	0	0	0
Range habitat	80	20	0	0
Trails	100	0	0	0
Roads-Forest Service	30	70	0	0
Roads-Co/State	20	80	0	0
Utility (power/gas) lines	40	60	0	100
Site preparation	75	25	0	100
Timber stand improvement	75	25	0	0

## 9. Alternative B

### Theme

Vegetation management is done to achieve maximum vegetation control within legal constraints. Number of acres treated and intensity and frequency of treatments increase from present levels. Acres treated per year total 17.4 percent of National Forest System lands in the Coastal Plain/Piedmont.

Use of herbicides broadcast at maximum rates, intensive mechanical tools, and intense prescribed fire increases from present. Repeat entries occur on highly productive land where competition and return on investment are greatest.



Most of the increase in acres is due to increased treatment frequency for hazardous fuels, wildlife habitat and range forage improvement, and corridor maintenance. But some is due to repeated timber stand improvement activities.

Substantial shifts from present mix of methods occur in precommercial thinning and roadside maintenance (from use of mechanical and manual methods to herbicides), pine release (from use of manual methods and prescribed fire to herbicides), and site preparation (from use of prescribed fire to mechanical methods and herbicides).

Aerial application of herbicides is allowed for most pine release, some site preparation and utility line maintenance, and a small amount of range forage improvement.

Only mitigation measures presently required apply. All those listed in section II.E apply except 1.h.(20,22), 2.a.(3,4,5,14), and 2.c.(3,4,5,6,13,14,17,18). Mitigation 2.c.(25), not required at present (aerial application), applies.

#### Methods and Tools

Herbicides: Herbicides are applied by hand (backpack sprayer, spotgun, hypo-hatchet, injector, axe/sprayer), machine (boom sprayer, granular spreader), and air (helicopter only). Major uses are timber stand improvement, roadside maintenance, and site preparation. More herbicides are broadcast in wildlife habitat and range forage improvement, roadside and utility line maintenance, site preparation, and timber stand improvement than in the other alternatives.

Mechanical: Low to high disturbance tools (mowing, chopping, shearing, ripping, scarifying, piling, bedding, light and heavy disking, raking) are allowed. Major uses are roadside maintenance and site preparation.

Prescribed Fire: Low to high intensity burns are applied by ground and aerial ignition tools. Major uses are hazardous fuel reduction, wildlife habitat improvement, and range forage improvement.

Manual: Hand (axe, blade, clipper) and power tools (chain saw, brush cutter) are allowed. Use of manual methods declines and is limited mostly to trail maintenance.

Biological: This method is not used.

Projected Average Treatment Frequency	Area Treated	Intervals (Years)
	Trails; County/State roads; Railroads; Gas lines	1
	T&E habitat; Range habitat; FS roads	2
	Power lines	3
	Hazardous fuels; Other wildlife habitat - Coastal Plain	3
	Hazardous fuels; Other wildlife habitat - Piedmont	5

Estimated Program	Method	Projected Acres/Yr	Percent Total Acres Treated
	Herbicides (ground)	37,385	4.7
	Herbicides (aerial)	28,000	3.5
	Mechanical	64,258	8.0
	Fire	667,074	83.3
	Manual	1,221	0.1
	Biological	3,053	0.4
		800,991	100.0

Projected acres/year by method by program:

Method						
Program	Herbicides		Mech.	Fire	Manual	Biol.
	Ground	Aerial				
Projected acres/year	37,385	28,000	64,258	667,074	1,221	3,053
Fuels treatment	0	0	0	294,796	0	0
T&E species habitat	85	0	84	8,178	84	0
Other wildlife habitat	4,119	0	1,239	211,346	0	0
Range habitat	3,926	1,000	0	98,103	0	0
Trails	63	0	63	0	1,137	0
Roads-Forest Service	10,238	0	15,358	0	0	0
Roads-Co/State	9,200	0	13,800	0	0	0
Power lines	70	900	2,262	0	0	0
Railroads	0	0	0	60	0	0
Gas lines	250	1,100	3,150	0	0	0
Site preparation	3,978	11,000	27,459	7,488	0	0
Timber stand improvement*	5,456	14,000	843	47,103	0	3,053

\*--Includes release, precommercial thinning, understory species treatments.

Percent of herbicides applied using selective versus broadcast techniques:

Program	Ground Applications		Aerial Application	
	% Selective	% Broadcast	% Selective	% Broadcast
Wildlife (incl. T&E) habitat	90	10	0	0
Range habitat	70	30	0	100
Trails	100	0	0	0
Roads-Forest Service	10	90	0	0
Roads-Co/State	10	90	0	0
Utility (power/gas) lines	20	80	0	100
Site preparation	50	50	0	100
Timber stand improvement	50	50	0	100

**C. ALTERNATIVES  
CONSIDERED, BUT  
ELIMINATED FROM  
DETAILED STUDY**

Full Vegetation Control With No Constraints: This alternative pursues complete vegetation control with no regard for floodplains and wetlands, threatened and endangered species, cultural resources, wilderness values, and other mandated constraints.

It was eliminated from detailed study because the little added competition control gained by violating laws and regulations that protect vital resources was not deemed reasonable or implementable.

No Prescribed Fire: This alternative eliminates the use of prescribed fire. Use of other methods, particularly mechanical and herbicide, increases to fill the void.

This alternative was eliminated because issues that address prescribed fire generally debate its intensity, timing, and frequency but support its use.

**D. DESCRIPTION OF  
METHODS AND TOOLS**

This section describes methods and tools proposed for use in the vegetation management program. Methods discussed are prescribed fire, mechanical, manual, herbicides, and biological. Regardless of the harvest cutting methods identified in Forest Land and Resource Management Plans, all of the tools described in this section are available for use as specified by each alternative.

**1. Prescribed Fire**

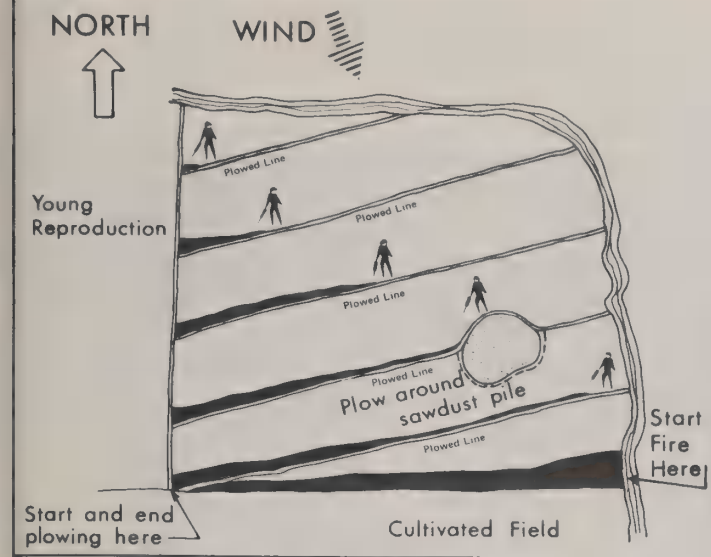


Prescribed fire is the planned use of fire. It is used to reduce hazardous fuels, prepare sites for seeding or planting, rejuvenate wildlife and range forage species, maintain fire-dependent species and ecosystems, control insects and diseases, and manage wilderness and threatened and endangered species and their habitat. Factors evaluated when using prescribed fire include project objectives, fuels (quantity, type, distribution, moisture content), topography (ruggedness, elevation, slope), weather (temperature, wind, humidity), time of year, smoke dispersal, and predicted fire behavior (flame length, rate of spread).

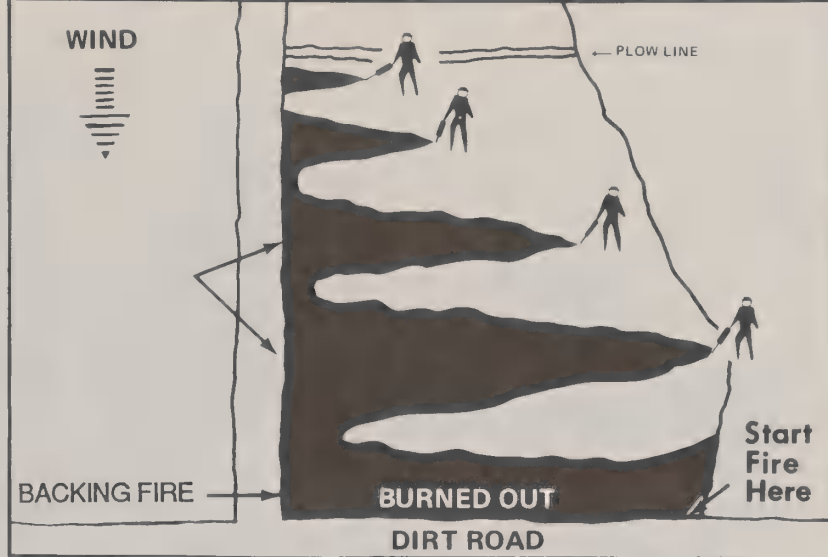
Firing techniques are the patterns used to dispense fire. The six techniques commonly used are backing fires, strip-head fires, flanking fires, spot fires, ring fires, and slash pile or windrow fires (figure II-1).

Backing fires consist of burning a fire against the wind. Strip-head fires are a series of parallel lines of fire set against the wind, perpendicular to wind direction; lines burn with the wind but never gain momentum before burning into the next line. Flanking fires are a series of lines of

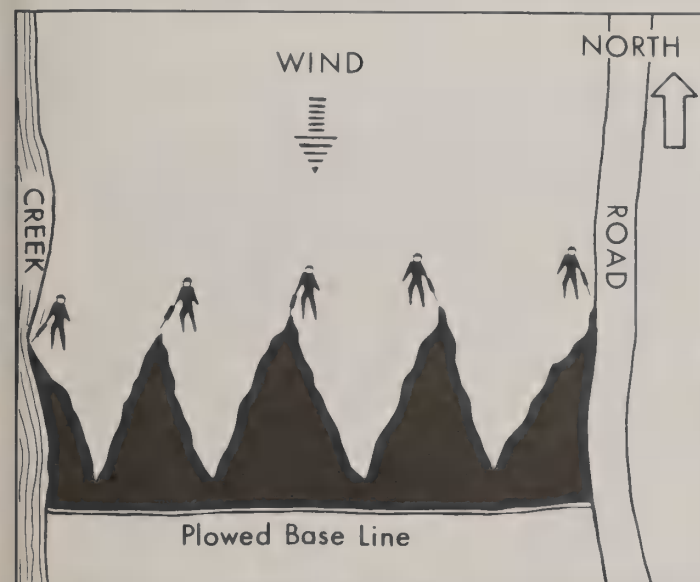




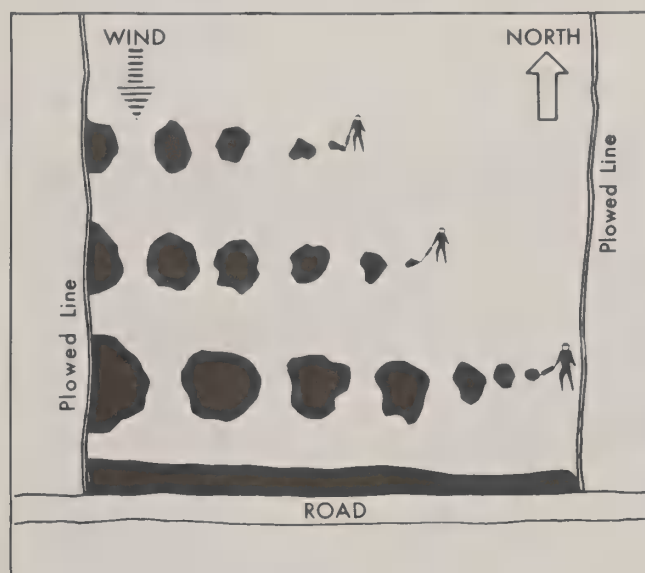
BACKING FIRE TECHNIQUE



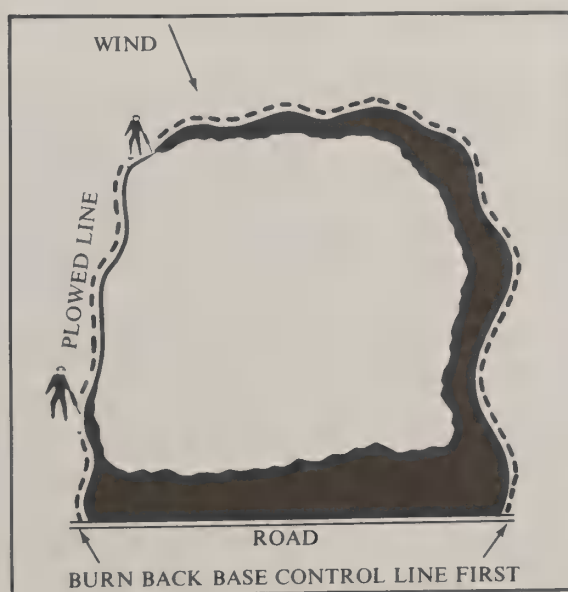
STRIP-HEAD FIRE TECHNIQUE



FLANK FIRE TECHNIQUE



SPOT FIRE TECHNIQUE



RING FIRE TECHNIQUE

Figure II-1.--Firing techniques.

fire set against the wind, parallel to wind direction, that burn out at right angles from the wind direction. Spot fires are a series of parallel fire spots (approximately 50 to 250 feet apart) set against the wind. The fires radiate out in all directions, minimizing fire momentum as they burn together. Ring fires are applications of a single line of fire completely around burn areas. Slash pile or windrow fires are applied to concentrated fuel piles.

Three types of ignition tools are commonly used in the Coastal Plain/Piedmont. The traditional ground-based system is the hand-held drip torch. The other two tools, which are aerial ignition systems, are the helitorch and plastic sphere dispenser. Choice of firing technique and ignition tool depends on project objectives, site conditions, and safety.

a. Hand-held  
Drip torch

Drip torches are small hand-held aluminum or stainless steel tanks that contain a mixture of gasoline and diesel fuel. A spout attached to the tank drips the fuel mixture onto a lighted wick. Lighted fuel falls to the ground igniting surface fuels. All six firing techniques can be applied using hand-held drip torches.

b. Helitorch

Helitorches are specially designed drip torches for application of ignited gelled fuel from helicopters. They consist of a 30- or 50-gallon fuel drum, an ignition and electric pump assembly, and frame and suspension system. The helitorch is suspended laterally beneath and to the front of a helicopter. The nozzle end of the torch is positioned on the same side as the pilot. The pilot controls flow and ignition of the gelled fuel. Gelled fuel is formed by adding a fuel thickening powder to regular gasoline or a 70-30 mixture of diesel fuel and gasoline. The strip-firing technique is most commonly used, although a helitorch can be used with all firing techniques.

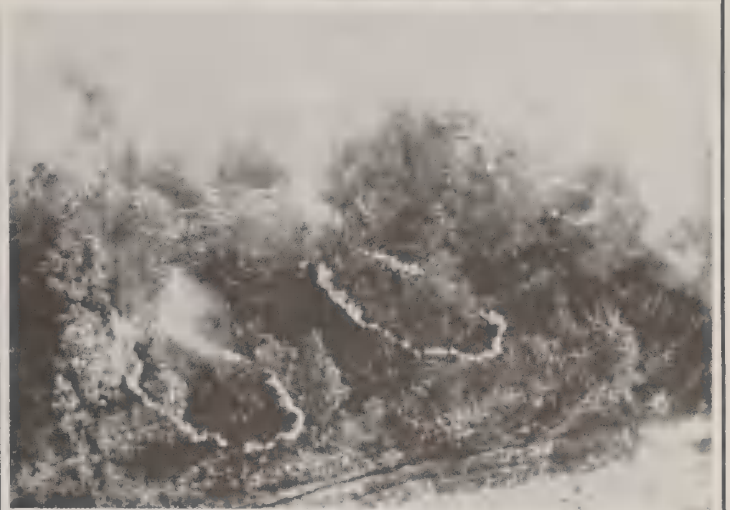
c. Plastic Sphere  
Dispenser

The plastic sphere dispenser is also applied using helicopters but the tool is mounted just inside the side door of a helicopter. The device ejects small spheres (commonly called "ping-pong balls"), made of high-impact polystyrene, approximately 1.25 inches in diameter, and filled with 3 grams of potassium permanganate (a dark purple salt used as an oxidizer). Immediately prior to ejection, the spheres are injected with about 1 milliliter of ethylene glycol (antifreeze). Spheres are dropped onto the treatment area at predetermined spacings (one or more per acre). After a delay of approximately 20 seconds, a reaction between the two chemicals ignites the sphere which sets fire to the surface fuels. The spot-firing technique is applied when using the plastic sphere dispenser.

PREScribed FIRE TOOLS



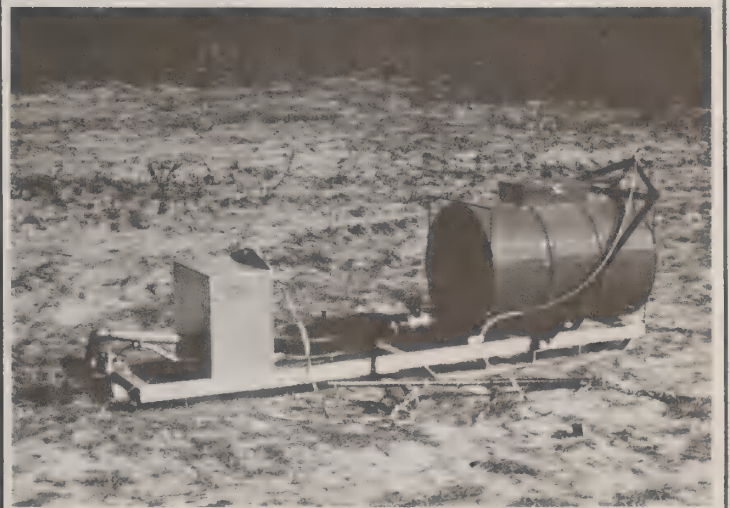
Aerial Ignition Device



Spot firing technique



Helitorch in operation



Helitorch



Hand held drip torch



Helitorch



## 2. Mechanical Methods

Nine types of mechanical tools are used in the Coastal Plain/Piedmont. They are divided into three categories based on their potential for soil disturbance by erosion, compaction, and nutrient loss. Potential soil disturbance is low for mowing, chopping, shearing, scarifying, and ripping tools; moderate for piling and bedding tools; and high for raking and disking tools.

### a. Mowing Tools

Mowing tools are rotary cutting devices that cut, chop, or shred vegetation on slopes up to 30 percent. Herbaceous species (grasses, grass likes, forbs) as well as woody species (vines, shrubs, trees) are cut near the ground line and are mulched and scattered, facilitating on-site decomposition and nutrient cycling. These tools are most effective on vegetation 3 inches or less in diameter. They are commonly used to maintain road and utility rights-of-way, refurbish wildlife food plots, and precommercially thin young stands. Since mowing tools cut vegetation above the ground line, little soil is disturbed.

Sprouting species require repeated treatments because they rapidly recover and compete with desirable vegetation. In addition, as the material is cut it can be ejected from the machine causing a safety hazard to workers or bystanders.

### b. Chopping Tools

The most common chopping tool is a single rolling drum chopper towed by a crawler tractor. It cuts and chops herbaceous and woody vegetation up to 5 inches in diameter and operates on slopes up to 35 percent. Vegetation is pushed to the ground and cut into small pieces as the chopper rolls over it. Chopping tools are used mainly for site preparation but they are also used for rights-of-way maintenance and precommercial thinning.

Vegetation is cut and chopped into small pieces, which helps decomposition and nutrient cycling. Depressions made by chopping blades also increase water infiltration and mixing of organic matter into the soil. Soil exposure and disturbance are minor.

Release treatments may be needed because of rapid recovery of sprouting species, and debris left in place may impair planting. Soil exposure can be significant at the upper end of the tool's slope range.

### c. Shearing Tools

Shearing tools are specialized cutting blades mounted on crawler tractors. The two types used are K-G ("angle") blades and V-blades. They are used on slopes up to 35 percent. Any size of herbaceous and woody vegetation can be cut just above the ground line. This equipment is used for site preparation and provides a cleared area ready for direct seeding or planting.

As material is pushed aside, topsoil can be displaced, which increases risk of erosion. Sprouting species recover quickly and compete with desired vegetation.

#### d. Scarifying Tools

Scarifying tools clear herbaceous and small woody vegetation; their rotating scalping blades form a shallow depression, 2-4 inches deep, with an adjacent pile of topsoil. The modified area is approximately 18 inches by 3 feet. Size and spacing of scalped areas can be varied. On the average, cleared areas are on a 7-foot by 7-foot spacing. Scarifiers are usually towed behind a crawler tractor or rubber-tired skidder on slopes up to 35 percent. They are used mainly for site preparation.

Scarifiers modify soil moisture and nutrient conditions. Depressions increase water storage, and adjacent piles have increased soil drainage and concentrated nutrients. Cleared areas are not continuous and ground cover between them is usually not disturbed, so risk of erosion and nutrient loss is very low.

Efficiency of scarifiers is reduced on steep slopes, shallow soils, and sites having many obstacles such as large rocks, stumps, or logs. Additional treatments, such as herbicide application alongside scalped areas or subsequent release after seeding or planting, may be necessary on sites with abundant understory vegetation to reduce competition around cleared areas.

#### e. Ripping Tools

Ripping tools (also called subsoilers or chisel plows) are large blades or shanks pulled through the soil at depths of 4 to 20 inches. Spacing between rips varies from 3 to 12 feet. The exposed soil ranges from 6 to 24 inches wide. Because of the blades' size and tilling depth, rippers are usually mounted on or pulled behind large farm or crawler tractors. Ripping is usually done on the contour of slopes up to 35 percent. Rips placed on the contour can be continuous, but rips not on the contour are broken up by lifting the blades out of the ground every 50 to 100 feet. Some wildlife habitat improvement projects use rippers, but they are mainly used for natural or artificial site preparation.

Rippers break up and mix compacted soils and improve soil porosity. This action forms a microsite more suitable for seeding or planting by improving soil drainage and available moisture. Risks of erosion are very low when ripping is done on the contour, but risks increase when done up and down slopes.

High amounts of logging slash or woody understory vegetation reduce ripping efficiency. Treatments such as prescribed burning or shearing and piling prior to ripping may be necessary on such sites to facilitate ripping.



MECHANICAL TOOLS (1)



Mowing tool - Shredder



Mowing tool - Hydro Axe



Mowing tool - Bush-hog



Ripping tool



Scarifying tool



Tandem rolling drum choppers



#### f. Piling Tools

Piling tools move logging slash and woody understory vegetation into piles or windrows. The piling tool is commonly called a brush rake or piling and stacking rake. It replaces the dozer blade on a crawler tractor and is used on slopes up to 35 percent. It is not solid like a standard dozer blade, but consists of a series of curved teeth spaced at intervals of 6 to 24 inches. The rake is held above the soil surface, and logging slash and brush are rolled forward into piles or windrows. Piling tools are used mainly for preparing sites for artificial regeneration.

Teeth of the rake do not penetrate the soil and are curved to produce a rolling motion of material being piled, which creates a moderate amount of soil disturbance. As the material is rolled forward, nearly all topsoil and much litter filter through the spacings between the rake teeth.

#### g. Raking Tools

Raking tools also move logging slash and woody understory vegetation into piles or windrows. Rakes are standard dozer blades or brush rakes mounted on a crawler tractor. They can operate on slopes up to 35 percent. Raking tools are used mainly for preparing sites for artificial regeneration.

Raking differs from piling. A standard solid dozer blade pushes material forward with little rolling action. This action causes logging slash, brush, litter, and some topsoil to be scraped into the piles or windrows. When using a brush rake, the teeth are lowered to penetrate the soil, uprooting and pushing herbaceous and small woody vegetation ("root-raking") as well as litter and some topsoil along with the logging slash and brush into the piles. Soil disturbance from raking is high.

#### h. Bedding Tools

Bedding tools plow, mix, and loosely pile topsoil and litter into elevated beds. Bedding is normally done on wet sites having slopes of 3 percent or less. Bedding tools consist of one or more sets of disks pulled by a crawler tractor. The disks plow toward each other, piling topsoil and litter into a bed. Some bedding tools utilize choppers or rollers behind the plowing disks to enhance bed settling and shaping. Beds range from 6 to 8 feet wide and from 12 to 18 inches high. After soil settling, bed heights range from 8 to 15 inches. Bedding tools are used for preparing sites for artificial regeneration. Prior to using bedding tools, treatments such as shearing followed by piling or raking are commonly used to remove logging slash or brush.

Mixing of topsoil and litter concentrates nutrients in the beds. In level wet areas, the small increase in elevation greatly improves soil drainage. Root systems of seedlings planted in beds become established in unsaturated soil, which improves seedling survival and growth rates.

Soil disturbance from bedding is moderate. Although soil exposure is high, erosion or nutrient loss from the site is low due to the flat terrain. Bedding can be used to break up compacted surface soils.

#### **i. Disking Tools**

Disking tools consist of one or more sets of disks pulled behind a farm or crawler tractor. Disks plow by tilling and mixing topsoil and litter to depths of 4 to 20 inches. Disking is usually done on the contour on slopes up to 30 percent. Disking tools are used for wildlife and range habitat maintenance and for preparing sites for artificial regeneration.

Disking is divided into light and heavy categories based on intensity of tilling. Light disking is done to shallow depths on small areas (usually less than 1 acre), in strips, or on slopes of 5 percent or less. Undisked strips act as filter strips that reduce soil loss. Examples of light disking are wildlife opening refurbishment and reseeding of logging roads and skid trails. Heavy disking is commonly done to greater depths over large areas at slopes steeper than 5 percent.

Efficiency of disking is reduced on areas with many obstacles, such as large rocks, logs, or stumps, which could damage disks. On areas with heavy logging slash or abundant brush, common treatments prior to disking include shearing followed by piling or raking. Disking can break up compacted surface soils.

#### **3. Manual Methods**

Manual methods use hand-operated powered or non-powered tools to cut, clear, thin, girdle, or prune herbaceous and woody species. Non-powered hand tools are axes, brush hooks, and hand clippers. Powered hand tools include chain saws and motorized brushcutters (weed eaters with a saw-type blade). Slope does not limit use of manual tools. Manual tools are most commonly used for timber stand improvement (release, precommercial thinning), corridor maintenance (especially trails), wildlife and range habitat improvement, and threatened and endangered species habitat improvement.

Manual cutting tools sever vegetation above the ground line; soil is seldom exposed. Residues are usually left intact on the treatment area, facilitating nutrient cycling as the materials slowly decompose. Heavy amounts of slash may initially cause an increase in fire hazard. Sprouting species rapidly recover and compete with desirable vegetation, requiring repeated manual treatments or the use of other treatments such as herbicides or prescribed fire.

#### 4. Herbicide Methods

Characteristics of the 11 herbicides used in the Southern Region are described below, as are 3 application methods: (1) manual ground, which uses hand-carried equipment; (2) mechanical ground, which uses truck- or tractor-mounted equipment; and (3) aerial, which uses helicopter-mounted equipment.

Herbicides are applied as either liquid sprays or granules. All spray-application tools are designed to produce large droplets to minimize drift. Relatively large and heavy granules are also designed to minimize drift.

New herbicides and application methods are periodically registered for silvicultural use. Prior to operational use, efficacy of the herbicide is evaluated through research and administrative studies on small areas. If the product is effective, an amendment to this EIS must be prepared which includes a toxicological background statement, a risk assessment, and analysis of the product's environmental behavior. Once testing, documentation, and public disclosure of findings are complete, field personnel are notified of the availability of the new herbicide or tool.

##### a. Herbicides Characteristics

Primary sources of information are product labeling information, material safety and technical data sheets, the Weed Science Society of America's Herbicide Handbook (1983), and the Southern Region's annual herbicide use reports. Individual sources are not cited for each bit of data.

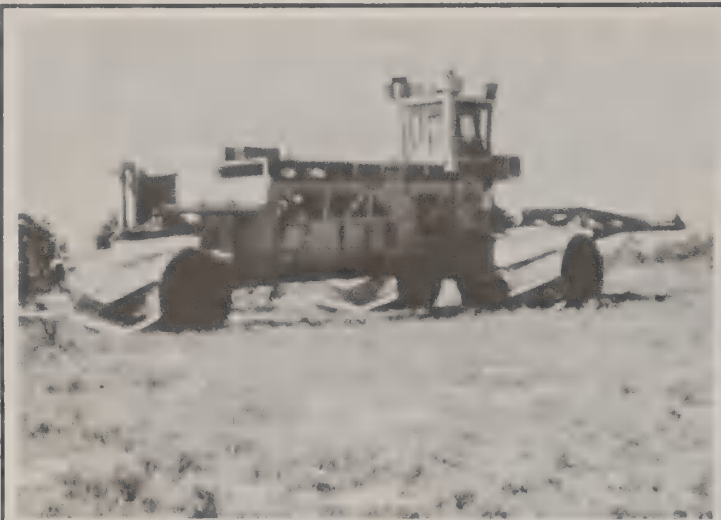
##### DICAMBA

TRADE NAME: BANVEL<sup>R</sup>, BANVEL<sup>R</sup> CST, BANVEL<sup>R</sup> 720, and others.

Dicamba is regularly used for broadleaf weed control in food crops including small grains, corn, sorghum, sugarcane, and asparagus. Additionally, it has labeled uses for weed control in turfgrass and utility rights-of-way. In forestry, its labeled use is for woody plant control in site preparation. In the South, dicamba is not widely used in forestry work. Methods of application include cut-surface treatments, basal spray, and foliar spray. Dicamba is readily absorbed and translocated by the roots, stems, and foliage of plants. In susceptible species, dicamba acts primarily as a growth regulator affecting shoot and root development. The degree of effect varies by species. Dicamba may be broken down by the plant or moved through the roots to surrounding soil. Dicamba may move in the soil, especially sandy soils. Micro-organisms biodegrade dicamba in soil. It persists in the soil from 3 to 12 weeks depending on weather.



MECHANICAL TOOLS (2)



Self propelled chopper



Disking tool



Bedding tool with bed settling attachment



Bedding tool with a bed shaping attachment



Shearing tool, V-blade



Piling tool - brush rake

### FOSAMINE

TRADE NAME: KRENITE<sup>R</sup>, KRENITE<sup>R</sup> S.

Fosamine ammonium is labeled for non-cropland brush control on railroads, rights-of-way, industrial plant sites, drainage ditch banks, etc., including land surrounding water supply reservoirs. In forestry it is seldom used, but is used for right-of-way maintenance. Method of application is foliar spray, and coverage must be complete to be effective. Fosamine is absorbed by foliage, stems, and buds of broadleaf plants. The effects of this herbicide are delayed, and following a fall application, bud development in the spring is prevented or severely limited. There is little or no leaching of fosamine through soil. Field tests have shown a half-life in soil of about 1 week.

### GLYPHOSATE

TRADE NAME: ROUNDUP<sup>R</sup>, RODEO<sup>R</sup>, ACCORD<sup>R</sup>, and others.

Glyphosate is commonly used in agriculture and as a home-use product. It controls a broad range of grasses, weeds, and woody brush species. Roundup is registered for uses on orchards, groves, vineyards, and in weed control prior to planting of grains, soybeans, corn, and other food crops. It is also registered for control of grass and weeds in recreational areas, schools, parking lots, other public grounds, and for non-crop areas, forests and silvicultural sites. Rodeo is labeled primarily as an aquatic herbicide, but is also labeled for forestry. Accord is registered for use on forest and industrial sites. Glyphosate is used in forestry for site preparation and release. Methods of application include cut-surface treatments and foliar spray. Glyphosate is readily absorbed by foliage and primarily affects plants by disrupting photosynthetic processes. Glyphosate has practically no leaching tendency because it binds tightly to soil. In soil, it is highly susceptible to degradation by micro-organisms, being converted to natural products such as carbon dioxide and water. Persistence in soils is about 2 months or less.

### HEXAZINONE

TRADE NAME: VELPAR<sup>R</sup> L, Velpar<sup>R</sup> ULW, PRONONE<sup>R</sup> 5G, PRONONE<sup>R</sup> 10G, and others.

Hexazinone is used to control a wide variety of grasses, weeds, and woody plants. Hexazinone has a number of food crop uses including weed control in blueberries, sugarcane, pineapple, and alfalfa. In forestry, it is commonly used for site preparation and release. Methods of application include foliar spray, basal soil applications, granular



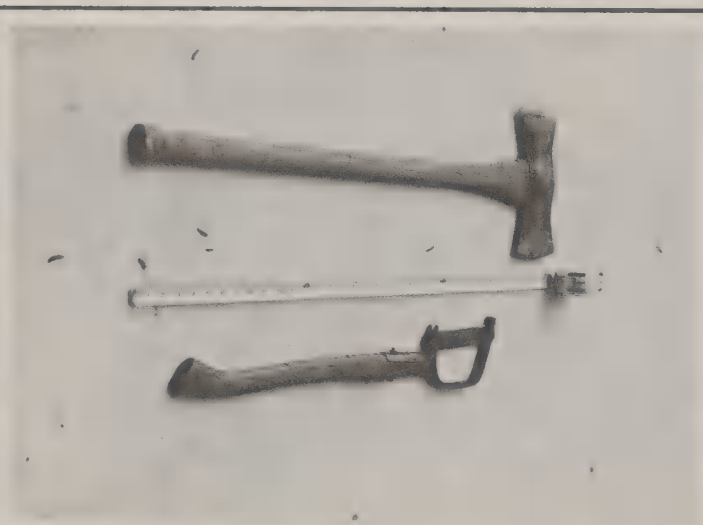
BIOLOGICAL AND MANUAL TOOLS



Cattle as a biological control tool



Powered hand tool - chainsaw



Brush axes



Brush hook



Brushsaw



Cattle as a biological control tool



applications to soil, and cut-surface treatment. Hexazinone is a "soil-active" herbicide, moves readily through soil, and is absorbed by plant roots with some foliage absorption. Herbicide activity and lateral and vertical movement is limited in soils high in organic matter or heavy clay. It may affect nearby desirable plants outside the treated area which have roots growing into the treated zone. Hexazinone primarily affects plants by inhibiting photosynthesis. The degree of effect on plants depends on susceptibility of the species, rate of application, and soil texture. In soil, hexazinone is subject to microbial degradation. It persists in soil from 1 to 6 months depending on soil and weather.

#### IMAZAPYR

TRADE NAME: ARSENAL<sup>R</sup>, ARSENAL<sup>R</sup> Applicators Concentrate, CHOPPER<sup>R</sup>, and others

Imazapyr is used for control of weeds, grasses, and woody plants in forestry including site preparation and release. It is also labeled for weed control under pavement at industrial sites and rights-of-way. Methods of application include cut-surface treatments, foliar spray, and basal bark spraying. Imazapyr is absorbed through foliage and roots and is rapidly moved throughout the plant. Imazapyr accumulates in growing tips of plants where it inhibits amino acid synthesis. It affects susceptible species slowly, yellowing newest leaves first and then spreading throughout the plant. Imazapyr can enter the soil, but lateral and vertical movement is limited. It persists in soil up to 12 months depending on soil type, amount used, and weather. It may affect nearby desirable plants outside the treated area which have roots growing into the treated zone. Imazapyr photodegrades and, to a lesser extent, biodegrades. Imazapyr has minimal effect on soil microflora.

#### PICLORAM

TRADE NAME: TORDON<sup>R</sup> 101, TORDON<sup>R</sup> 101R, TORDON<sup>R</sup> K, and others.

Picloram's uses include noxious weed control, rights-of-way, facilities maintenance, and rangeland improvement. In forestry it is used to control woody plants and weeds. Methods of application include cut-surface treatments and foliar spray. Picloram is primarily a growth regulator. Herbicidal action is a result of absorption through leaves and some uptake through roots. It is easily translocated in plants and accumulates in new growth causing leaves to cup and curl. Picloram is water soluble and can move in sandy soils low in organic matter. It may affect nearby desirable

plants outside the treated area which have roots growing into the treated zone. Degradation by soil micro-organisms is slow and primary breakdown is by ultraviolet light. Persistence in soils varies by type of soil and weather but may exceed 100 days.

#### SULFOMETURON METHYL

TRADE NAME: OUST<sup>R</sup>.

Sulfometuron methyl is a broad spectrum, pre- and post-emergence herbicide. Its labeled uses include selective weed control in turf grass, roadsides, and other non-cropland applications. It is registered for control of undesirable herbaceous plants in pine reforestation sites. The method of application normally is foliar spray. Sulfometuron methyl is absorbed through plant leaves, with some absorption by roots. In the plant, it suppresses and stops plant growth by arresting cell division in growing tips. Sulfometuron methyl is hydrolyzed in soil and persists approximately 4 weeks.

#### TEBUTHIURON

TRADE NAME: SPIKE<sup>R</sup> (several formulations), GRASLAN<sup>R</sup>, and others.

Tebuthiuron is a broad-spectrum, soil-applied herbicide used for weed and brush control in range, pasture, and non-cropland applications. Its labeled uses include control of woody plants and weeds for maintenance of utility rights-of-way. It is usually applied to the soil as a granule, pellet, or wettable powder. The mode of action of tebuthiuron in plants is to inhibit photosynthesis. It is slowly absorbed by plant roots and may take up to 3 years to kill some species. Tebuthiuron is moderately mobile in most soils and is persistent from 1 to 3 years. It may affect nearby plants outside the treated area that have roots growing into the treated zone. It is primarily broken down by soil micro-organisms.

#### TRICLOPYR

TRADE NAME: GARLON<sup>R</sup> 3A, GARLON<sup>R</sup> 4, and others.

Triclopyr is a broad-spectrum herbicide originally developed for control of vegetation along utility rights-of-way and on industrial sites. In forestry, it is labeled for site preparation and release. Methods of application include cut-surface treatments, foliar spray, and basal bark spray. Triclopyr is primarily absorbed by plant leaves and is readily moved throughout the plant. It affects plants by

interfering with normal growth processes. In soil, triclopyr is not highly mobile. It is rapidly broken down by soil micro-organisms and ultraviolet light, persisting an average of 30-56 days depending on soils and weather. Its half-life in water is about 10 hours at 72°F.

#### 2,4-D AND 2,4-DP

TRADE NAME: WEED RHAP A-4D<sup>R</sup>, Weedone<sup>R</sup> 2,4-DP, Esteron<sup>R</sup> 99, and others, and as a major component of Tordon 101\* and Tordon 101<sup>R</sup>.

2,4-D and 2,4-DP are used to control broadleaf plants in food crops, pastures, lawns, rights-of-way, and range lands. They are used for brush and kudzu control in forestry. Labeled uses include site preparation and release. In the South, 2,4-D is not widely used in forestry work. Methods of application include cut-surface treatments, foliar spray, and basal bark sprays. Amine formulations are generally used for cut-surface treatments and esters for foliar spray and basal bark applications. 2,4-D and 2,4-DP are hormone-type growth regulators. They are absorbed by plant leaves, stems, and roots and moved throughout the plant. Accumulation occurs in growing tips. Salts of 2,4-D can move in sandy soils. Soil micro-organisms break them down in 1 to 4 weeks.

b. Manual Ground Tools Tools used for manual ground application deliver herbicide in a variety of ways. Application of liquids includes basal, soil-spot, foliar, and cut-surface treatments. Granules can be applied by hand or a hand-held spreader.

Liquid Application Basal applications are used for release, precommercial thinning, and right-of-way maintenance, though some site preparation work is also done this way. A spray gun or wand is used to direct the spray at a target stem. Two types of basal applications are used:

- Full basal treatments are applied to trees up to 5 inches in diameter. The lower 12 to 20 inches of the stem are wet with herbicide on all sides.
- Streamline treatments are applied to smaller juvenile stems. Herbicide is applied to one side of the stem in a 1.5- to 2-inch band.

Soil-spot applications are used for site-preparation and release (and some right-of-way) treatments. A soil-active herbicide is sprayed onto the soil in the treatment area. Three basic patterns of spray application are commonly used:



- Spot grid treatment is commonly used on sites with many stems per acre. Spots of herbicide are applied to the soil in a regular pattern.
- Individual stem treatment is applied by spraying the soil around unwanted plants.
- Spot-around treatments are made by spraying herbicide spots on the ground around the desired plant.

Foliar applications are used to release first or second year stands from competition. Liquids are sprayed onto leaves of target plants in full leaf and growing.

- Directed foliar spray application is used to release young stands from competition that is less than 6 feet tall. Herbicide is generally applied to hit target vegetation but miss desired plants.
- Herbaceous weed control is done by applying herbicide directly over the top of all plants including desired plants to control competing vegetation. Herbicide is sprayed in a 4-5 foot circle or in a continuous band.

Cut-surface treatments are used to eliminate competing trees or control resprouting of stumps during site preparation, precommercial thinning, and release. Three types of treatments are used:

- Tree injection, in which herbicide is placed directly within the wood of a tree by an injector, is most efficient on sites with sparsely distributed stems greater than 2 inches in diameter.
- Frill or girdle treatments involve cutting through the bark with an axe or hatchet to expose the cambium. The cut surface is then completely wet with herbicide. Girdles are formed by a completely encircling ring of cuts. Frilling generally results in a less complete ring of cuts.
- Cut-stump treatments are applied to stumps of any size to reduce sprouting. A sprayer is used to thoroughly wet the cambial area (about the outer 1 inch) of the stump.

Spray solutions are normally carried in backpack tanks, which hold between 1 and 5 gallons. These tanks have a diaphragm pump with a lever which allows the worker to pressurize the



tank. Herbicide is applied to the target via a hand-held gun or wand attached to the tank by a flexible hose. Within the gun or wand mechanism is a valve system controlled by a trigger, which allows the worker to start or stop application of the chemical. Application is made as a continuous flow or as a predetermined volume of liquid per pull of the trigger. Depending on type of nozzle used in the gun or wand, a large-droplet spray or a continuous stream of liquid is delivered.

The purpose of the project determines the type of tool used. To fully cover foliage (broadcast application), a gun or wand which dispenses a continuous flow of chemical through a spray nozzle is commonly used. Should a directed spray be desired (selective treatment), a spotgun or wand and a stream nozzle are most commonly employed. When treating freshly cut stumps, a continuous stream of herbicide from a spotgun or wand is used to soak the cambial area of the stump.

Sprays can drift, while continuous streams can splash back off the target vegetation. Tank weight makes the worker more subject to tripping in uneven terrain. Improperly maintained equipment is likely to leak on the worker. The hose between the backpack and hand unit can snag on vegetation and break, causing a spill of chemical directly onto the worker.

Tree injectors are closed hollow tubes (liquid tanks) which are refilled at the top and deliver liquid through a valve at the bottom. The valve end of the injector has a 1 to 2 inch blade used to cut through tree bark to expose the cambium. The injector is jabbed into a tree, a lever or string (trigger) is pulled, and herbicide is delivered into the cut.

A second form of injector is a modified hatchet called a hypo-hatchet. The cutting edge is about 1 to 2 inches wide and a hose and valve system are added. The hose connects the hatchet with a container attached to the applicator's belt. Herbicide is discharged into the cut by gravity and a piston system each time the hatchet is used.

A combination of injection and spraying using an axe and hand-held sprayer is called hack-and-squirt. A narrow-bladed hatchet is used to cut the bark of the target tree and a squirt bottle (held in the other hand) is used to apply herbicide to the cut.

All injection methods are target specific and are useful where selectivity is desired. These tools are most efficient where target plants are sparsely distributed and stems are larger than 2 inches in diameter.

Injecting trees is a labor-intensive activity, so worker fatigue and safety can become limiting. Injector nozzles clog with bark and wood chips and need to be cleaned frequently. Splash from injecting into cuts causes the tool to become coated with herbicide during the workday. The hypo-hatchet is very sloppy if not carefully maintained. Moreover, workers can be exposed to spray during the cut stroke and when the tool is removed from the cut. Squirt bottles used in hack-and-squirt are difficult to maintain and leak after only limited use.

#### Granule Application

Granules are manually applied by hand or hand-held spreaders. Treatments can be either selective or broadcast.

- Broadcast treatments scatter herbicide granules in a relatively uniform pattern over the treated area.
- Selective treatments locate target and non-target vegetation and place the granules either near target plants (to reduce their growth), or away from a desirable plant (to release it as in spot-around).

To hand-spread granules, only a sack and personal protective equipment are needed. Wearing gloves, workers carry the herbicide in a sack and throw the granules onto the ground. Hand-held spreaders are generally fertilizer spreaders: hoppers with a crank-operated rotating disk attached below. Granules pass through a small opening in the hopper onto the disk and are thrown from it when the crank is turned.

Granules are most commonly applied for site preparation, release, or right-of-way maintenance. They pose less risk to workers than liquid herbicides since there is less exposure to the herbicide (appendix A).

Granules require rain to release them into the soil where they become active, but they are subject to surface runoff in heavy rainfall. Additionally, they can bounce on impact and often tend to roll to the bottom of a furrow. This localized accumulation of granules can result in uneven control of vegetation.

#### c. Mechanical Ground Tools

Many mechanical systems are available to apply herbicides. Units are available to mount on crawler or rubber-tired tractors, skidders, tree shearers, or truck beds.

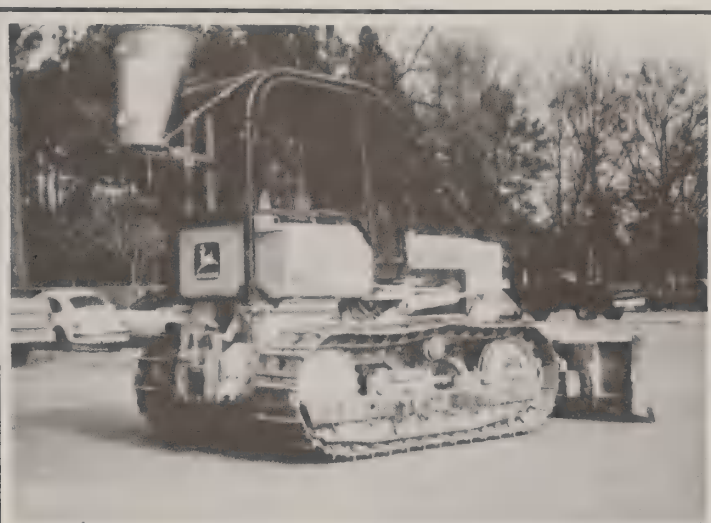
Mechanical ground equipment is normally designed to broadcast granules or sprays. Risk of exposing the applicator to herbicide is less than for manual ground methods. In addition, fewer workers are required.



## HERBICIDE TOOLS



Injector



Granular spreader



Hypo-hatchet



Backpack sprayer with spotgun attachment



Axe and sprayer



Helicopter spraying

All mechanical ground tools are subject to site-related restrictions; slope, soil, and proximity to streams must be evaluated to determine tool suitability. These methods allow for large-area coverage in a relatively short time, but they are not target selective; selectivity results from choice of, rather than placement of, herbicide.

#### Liquid Application



Mechanical tools for dispensing liquid herbicides have some common features. All have a tank (generally 25-300 gallons), a pump, a delivery system which controls the flow of herbicide, and nozzles which produce large spray droplets. The shape of many parts and overall configuration of the tool vary greatly, based on economics and proposed use. Most sprayers are controlled by the driver of the machine, though some require an operator in addition to the driver. Sprayers are commonly mounted on crawler tractors for use in forestry settings, though rubber-wheeled tractors or skidders are sometimes used. For roadside maintenance, truck-mounted units are most common.

Fixed-position booms similar to those used for agriculture (20-foot-wide boom with as many as 21 nozzles mounted at uniform intervals) are sometimes used in forestry or right-of way maintenance. It is, however, more common to see one or two clusters of "raindrop"-producing nozzles mounted on a short movable boom. A long boom (15 feet) has been developed for doing release work in heavily wooded areas. The boom is mounted vertically at the back of a crawler tractor with the nozzles broadcasting herbicide down onto vegetation.

The most common application pattern for mechanical sprayers is broadcast spray in narrow or wide bands. Electric systems, however, allow operators to vary position of boom and placement of spray with a fair degree of accuracy. Electric boom-positioning controls are more common on units designed for roadside maintenance.

#### Granule Application

Granule spreaders are large, rugged units powered by the machine on which they are mounted or by an independent power source. The spreaders either throw or blow the pellets through a dispensing tube.

They are used primarily for site preparation or release where broadcast application is appropriate. Granules tend to bounce and roll on impact, often rolling together in small depressions. This can cause spotty results or too much herbicide in one area.

#### d. Aerial Tools

Application by helicopter is the only aerial method evaluated. Granules and liquids can be applied aerially. The herbicide tank or hopper is mounted outside the cabin, reducing pilot exposure to the chemical. Due to the large



amount of herbicide which can be applied daily, the mixer/loader faces greater exposure risk than in a mechanical ground project. Aerial application requires very few workers.

Aerial methods are useful for site preparation, release, and right-of-way maintenance. Aerial delivery systems are most effective on larger areas. Due to buffer requirements and economics, aerial treatment is rarely practical for less than 20-acre blocks.

Drift is a primary concern during aerial operations. Uniformly large droplets and relatively heavy pellet weight sharply reduce drift. Care must be taken, however, to ensure proper safety standards.

Aerial operations are broadcast applications, and the pilot has limited ability to treat specific target plants. He can manipulate position and speed of his aircraft, can start or stop herbicide flow, and often has control of the flow rate of the herbicide. But these controls are rather inexact when compared with manual ground applications. Selection of the proper herbicide is critical to the success of an aerial application project.

#### Liquid Application

Aerial systems for applying liquids are boom/nozzle systems such as the microfoil boom. The system generates streams of liquid which, in the wake of the boom, break into droplets as a result of air turbulence. Droplets formed in this manner are relatively large and uniform. Another system being tested (through-the-valve boom or TVB system) is also designed to generate large droplets. Booms are mounted in static air below and in front of the helicopter; but flow is controlled by the pilot. Herbicide tanks used in the Region contain a maximum of 100 gallons.

#### Granule Application

A specially designed spreader is suspended below the helicopter. Air flow through the mechanism distributes the granules in the helicopter's wake. The hopper and feed mechanism is outside the cabin but controlled by the pilot.

#### e. Herbicide Use Classification

Table II-1 is a classification of herbicide/method combinations. It assumes typical application rates and typical exposures (tables 4-4 through 4-6, appendix A). It also assumes that all mitigation measures described in this chapter are in place. Combinations of chemicals and application methods are classified as follows:

- ° Class A - Do not pose risk which would require mitigation in addition to those stated in chapter II (section E.2.c.).



Table II-1.--Classification of chemical/method combinations when used at typical rates and exposures (tables 4-4 through 4-6, appendix A)

Class <sup>1</sup>	A	B	C	D
Manual ground: Cut surface	DIC; GLY; IMZ; PIC; TRA	2,4-DA		
Basal stem	DES; KER; LIM; TRE; 2,4-DP	2,4-DE		
Soil spot	HEX	TEB		
Foliar spray	FOS; GLY; HEX; IMZ; KER; LIM; PIC; SMM; TRA; TRE	2,4-DA; 2,4-DE; 2,4-DP	TEB	
Mechanical ground	DES; DIC; FOS; GLY; HEX; IMZ; PIC; SMM; TRA; TRE; 2,4-DP	2,4-DA; 2,4-DE; TEB		
Aerial	DES; FOS; GLY; HEX; IMZ; KER; LIM; PIC; SMM; TRA; TRE; 2,4-DP	2,4-DA; 2,4-DE; TEB		

KEY: 2,4-DA = 2,4-D Amine  
 2,4-DE = 2,4-D Ester  
 DIC = Dicamba  
 DES = Diesel  
 FOS = Fosamine

GLY= Glyphosate  
 HEX = Hexazinone  
 IMZ = Imazapyr  
 KER = Kerosene  
 LIM = Limonene

PIC = Picloram  
 SMM = Sulfometuron Methyl  
 TEB = Tebuthiuron  
 TRA = Triclopyr Amine  
 TRE = Triclopyr Ester

<sup>1</sup> Class is based on the analysis in the risk assessment (appendix A). ANY change from conditions evaluated in the risk assessment will affect proper placement of the chemical/method combination within the table. This table is intended for use in general forest or right-of-way conditions. Where threatened, endangered, proposed, or sensitive species are present appropriateness of the chemical/method combination will be determined during the project environmental analysis.

- Class B - Pose human or wildlife health risk which requires additional mitigation, OR have soil-active half-lives (appendix A, table 4-9) exceeding 6 months.
- Class C - Pose human or wildlife health risk which requires additional mitigation, AND have soil-active half-lives (appendix A, table 4-9) exceeding 6 months.
- Class D - Pose a risk to human or wildlife health or to the environment which cannot be mitigated to an acceptable level of risk.

When additional mitigation is required, several options are available: select a different herbicide; reduce amount of herbicide applied per acre; shorten the workers' work day; change method of application; etc. Selection of additional protective measures is done during site-specific project analysis.

## 5. Biological Methods

Biological methods intentionally use living organisms to suppress, inhibit, control, or eliminate growth of herbaceous and woody vegetation. For the purpose of this EIS, only grazing by domestic livestock within current grazing allotments that can effectively contain the animals is evaluated as a viable biological control method.

Researchers are currently evaluating other potential methods of biological control. Some experimental methods show promise but are not yet operational for forestry. These methods include microbial and viral agents (biological herbicides); plant pathogens, insects, nematodes, genetics (natural adaptability and plant breeding); competition (interspecific); allelopathy (plants affecting other plants through chemical inhibitors); and biodegradable mulches. When any of these methods is determined to be successful at operational levels, it will be evaluated for use in the vegetation management program. Its use will then be coordinated through all applicable State and Federal programs and regulations.

On national forests, domestic livestock such as cattle, horses, sheep, and goats are in limited use as biological control methods primarily in the western United States. Little use has occurred in the East. The objective is vegetation control through prolonged grazing, not animal weight gain. Numbers of livestock in an area are increased to a point where target vegetation is effectively controlled. Once the project objective is achieved, stocking levels are returned to normal allotment guides.

Effectiveness of grazing for vegetation control depends on size of area, amount of control needed, types and amounts of herbaceous and woody species present, and feeding selectivity of animals used. For example, on an area where

herbaceous species are to be controlled, cattle may be appropriate because they are more likely to graze grasses, grass-like plants, and forbs. Where woody species are to be controlled, goats may be more appropriate because a higher component of their diet consists of woody browse species.

Desirable herbaceous and woody species are susceptible to overbrowsing and trampling. Moreover, risks of soil erosion and compaction are high from overgrazing. Conflicts with wildlife can also occur in areas with habitat limitations or restrictions (such as seasonal food shortages). Location of water sources, proper fencing or herding requirements, availability of livestock, and economics can also be limiting factors.

## **E. MANAGEMENT REQUIREMENTS AND MITIGATION MEASURES**

This section describes management requirements and mitigation measures. Management requirements set direction on how resources are managed (such as timber stocking standards). Mitigation measures are actions taken to lessen adverse impacts or enhance beneficial effects (such as streamside protection). The requirements and measures do not apply to alternative A, in which no treatments occur. Most apply to all the other alternatives, but several are identified as applying to only some alternatives. There are two groups:

General management requirements and mitigation measures apply to all methods.

Method-specific management requirements and mitigation measures pertain only to specific methods and are in addition to the general requirements and measures. Combinations of methods vary by alternative so the applicability of individual requirements or measures varies. For example, alternative D excludes the use of herbicides. Any measure or requirement about herbicides does not apply to it.

### **1. General Management Requirements and Mitigation Measures**

The following general requirements and measures apply to all vegetation management methods. **Each forest may be more restrictive, but not less.**

#### **a. Site-Specific Analysis**

(1) Projects must have site-specific analysis in compliance with the National Environmental Policy Act (NEPA). This environmental analysis considers site-specific techniques, intensity of application methods, and potential environmental effects of any method considered. A reasonable range of alternatives, including one which does not use herbicides and a "no action" alternative, is examined.



Potential direct, indirect, and cumulative effects are evaluated. Effects to be considered include long-term soil productivity, water quality, air quality, vegetation diversity, wildlife, fish, cultural resources, civil rights (including those of minorities and women), and threatened, endangered, proposed, and sensitive species.

The intent of this requirement is to ensure adequate environmental analysis. Congress and the Council on Environmental Quality have recognized the effectiveness of NEPA in developing environmental awareness and protecting the human environment. Monitoring is done through review of site-specific analyses and post-treatment evaluations.



(2) A biological evaluation of how a project may affect any species Federally listed as threatened, endangered, or proposed, or identified by the Forest Service as sensitive, is done as part of the site-specific environmental analysis. This evaluation considers all available inventories of threatened, endangered, proposed, and sensitive species populations and their habitat for the proposed treatment area. When adequate population inventory information is unavailable, it must be collected when the site has high potential for occupancy by a threatened, endangered, proposed, or sensitive species. Appendix D identifies potential adverse effects from vegetation management by species. When adverse effects are projected, mitigation measures specified in appendix D and this chapter are used to prevent them.

Requirements and measures for actions affecting threatened, endangered, or proposed species are detailed in species recovery plans and FSH 2609.23R. Recovery plans have been

prepared for the southern bald eagle, red-cockaded woodpecker, wood stork, Mississippi sandhill crane, gray bat, Indiana bat, eastern indigo snake, and Harpers beauty. Chapters in FSH 2609.23R have been prepared for red-cockaded woodpecker, southern bald eagle, Mississippi sandhill crane, and American alligator. Requirements and measures for actions affecting sensitive species are detailed in Forest Land and Resource Management Plans.

If it is determined that the project may positively or negatively affect threatened, endangered, or proposed species, consultation is initiated with the Fish and Wildlife Service. If, during informal consultation, it is determined that the project is not likely to adversely affect listed species and the Fish and Wildlife Service so concurs in writing, consultation is terminated. However, if it is determined that the project is likely to adversely affect listed species, formal consultation is initiated. Figure D-1 outlines this process.

When the evaluation indicates that a project may have an adverse effect on a sensitive species or its habitat, appropriate State wildlife agencies, natural heritage commissions, and other cooperators or species authorities are contacted to identify coordination measures. These measures are directed towards ensuring species viability and preventing negative population trends that would result in Federal listing.

The intent of this requirement is to protect threatened, endangered, proposed, and sensitive species. Monitoring is done through review of site-specific analyses, onsite inspections, and post-treatment evaluations.

(3) Integrated Pest Management (IPM) principles are used during site-specific analysis. IPM is a decision-making and action process which includes biological, economic, and environmental evaluation of pest-host systems to manage pest populations.

IPM strategies apply a comprehensive systems approach to silvicultural, wildlife, range, recreation and corridor management practices that emphasizes prevention of pest problems. These strategies consist of a range of practices that include prescribed fire, manual, mechanical, biological, and chemical tools that may be used alone or in combination. Risk rating systems and pest incidence surveys are used during site-specific analysis. Further IPM direction is provided in FSM 3400, FSH 3409.11, and Forest Land and Resource Management Plans.

The intent of this requirement is to ensure use of IPM during project planning. It does not apply to alternative A (no vegetation management) and is severely constrained in alternative D (herbicides not used). Monitoring is done through review of site-specific analyses, onsite inspections, and post-treatment evaluations.

(4) In each project, water quality is protected from nonpoint-source pollution through use of preventive "best management practices" (BMP's). Implementation of BMP's, monitoring and evaluation of their application and effectiveness, and adjustment of practices as needed are done to protect beneficial water uses and comply with State water quality laws.

BMP's are applied to all activities in all alternatives. Some BMP's required to protect water quality appear in this section as mitigation measures for soil and water. BMP's applied in projects may be more stringent and more effective in protecting water quality, but not less. In each project, site-specific conditions must be assessed, and the BMP's specified here, plus any others needed to meet State water quality standards, must be employed.

The intent of this requirement is to protect water quality and assure compliance with State water quality laws. Monitoring is provided through evaluation of BMP application and analysis of water quality.

b. Timber Stand Improvement (TSI)

(5) Methods that maintain stocking levels (stems per acre) and improve growth rates are used (table II-2).

Table II-2.--\*Southern Region restocking standards: number of desirable stems per acre.

Forest Type	Lower Level	Target Level	Upper Level
Loblolly pine	300	500-700	900
Shortleaf pine	300	500-700	900
Slash pine	300	500-700	900
Longleaf pine	400	600-900	1,200
White pine	150	250-350	500
Virginia pine	300	500-700	900
Sand pine	300	500-700	900
Mixed pine-hardwood	300	400-600	900
Hardwoods (all species)	150	250-350	500

\* Stocking levels shown are guides, and must be used in conjunction with professional judgment to determine restocking levels for a specific site.



(6) Pine stands receive release and weeding necessary to meet growth rates and stocking levels established in Forest Land and Resource Management Plans. Stands are considered for release when the desired seedlings are not free to grow, when competing growth threatens to overtop and compete directly for sunlight, moisture, and nutrients, or when competition results in less-than-average growth for comparable sites.

(7) Precommercial thinning of pine (usually done before age 10 to 15 years) is considered when stem density exceeds the upper level of restocking standards.

(8) Hardwood stands are generally not released. Clumps of competing stems are removed, however, where they may interfere with desired trees.

(9) Hardwood stands, where codominant trees of seedling (not sprout) origin are 25 feet or taller, are considered for precommercial thinning.

The purpose of requirements (5) through (9) is to achieve species compositions and stand structures that reflect healthy, productive site conditions. Knowledge gained through research and many years of management experience and contained in silvicultural guides have shown these measures to be effective. Monitoring is accomplished through periodic inventories.

#### c. Soil, Water, and Aquatic Life

(10) Channel stability of perennial and intermittent streams is protected by retaining all woody understory vegetation within at least 5 feet of the bank and by keeping slash accumulations out of the stream.

This measure protects streams from excess channel erosion by avoiding channel obstructions and maintaining living root systems on banks. Beasley (1979), Patric (1976), and Ursic (1975) show its importance in controlling channel erosion. Monitoring is accomplished through project plan reviews and onsite inspections.

#### d. Cultural Resources

(11) A cultural resource inventory is conducted when soil disturbing activities are planned. An archaeologist performs a field survey to determine significance of and protection required for cultural resource sites. Significant sites are evaluated for eligibility to the National Register of Historic Places and are submitted to the State Historic Preservation Office for review.

(12) If archaeological or historic resources are encountered during soil disturbing activities, work stops until an archaeologist evaluates the site's significance.



The intent of measures (11) and (12) is to identify and preserve significant cultural resources. They ensure compliance with Federal and State laws protecting cultural resources. Monitoring is done through onsite inspections and post-project evaluations.

e. Safety

(13) Safety equipment for Forest Service workers (such as hard hats, eye and ear protection, chaps, and fire retardant clothes) is worn as determined by a Job Hazard Analysis specified in the Health and Safety Code Handbook (FSH 6709.11). This analysis estimates risks to specific body parts and prescribes needed protection.

The purpose of this measure is to reduce the number and severity of accidents. Experience and analysis of past accidents allow for effective measures to prevent future occurrences. Monitoring is done through onsite inspections and reviews of accident reports.

f. Visual Quality

(14) Visual Quality Objectives (VQO's) are met by corridor maintenance, site preparation, timber stand and wildlife habitat improvement, range forage, and fuels treatment projects. These VQO's are:

Preservation allows only for change not caused by humans. Generally, no treatments are permitted.

Retention ensures that human activities are not evident to the casual forest visitor. Concern for visual quality is primary. Visual impacts should be eliminated during or promptly after treatment. Many treatments are allowed, but raking, piling, disking, bedding, and broadcast herbicide methods are usually not appropriate.

Partial Retention means that human activities may be evident but remain subordinate to the characteristic landscape. Concern for visual quality is high. Visual impacts should be eliminated at a minimum within the first year. Most treatments are allowed, but disking, bedding, and broadcast herbicides are limited. In corridors, all methods and tools are available.

Modification indicates that human activity may dominate the characteristic landscape. Treatments should borrow established line, form, color, and texture so completely that visual characteristics are compatible with natural surroundings. All methods and tools are available for use.

Maximum Modification means that human activity may dominate the landscape, but should appear as a natural occurrence when viewed as background. All methods and tools are used, and at a greater intensity than in modification VQO.

(15) Treatments are scheduled as much as possible for the season that best meets VQO's. Rehabilitation and enhancement work may be needed to meet short-term VQO's. Visual diversity along active travelways (such as canopy layering, flowering trees) is protected from treatments where feasible and needed to meet VQO's. Tool selection and coordination requirements are determined by a site-specific analysis at the project level.

Measures (14) and (15) ensure consideration of visual quality objectives established in Forest Land and Resource Management Plans. Experience shows that meeting established visual quality objectives is effective in protecting the visual resource. Monitoring is done through onsite inspections and post-treatment evaluations.

#### g. Wildlife

(16) Wildlife stand improvement (WSI) seeks to improve vegetation species composition in timber stands and to develop wildlife habitat areas for game and nongame species. A variety of woody and herbaceous species suited to site conditions and burning regime are maintained to assure year-round quality habitat. Exceptions that may reduce plant species variety include treatments to improve habitat for species such as red-cockaded woodpeckers.

(17) For understory species WSI, proper management allows full sunlight on 30 percent of the forest floor. For hardwood overstory WSI, thinning encourages full crown development, vigorous growth, and soft or hard mast production. When thinning stands older than 30 years, stems are favored which show positive indication of bearing soft- or hard-mast.



(18) During TSI, WSI, and site preparation, selected groups of overstory and understory vegetation are protected and managed to assure a variety of soft-mast, hard-mast, and cover species. During site preparation, active and potential den trees are retained in clumps (at least 1/2 acre per 20 acres) if they are not provided in adjacent stands not suitable for timber production, inclusions, or streamside management zones. During TSI and WSI, all recognized den trees are protected. In addition, during TSI, WSI, and site preparation, an average of at least 2 standing dead snags are retained per acre, in the form of large hardwood trees (greater than 12 inches) when possible. Appropriate treatments are used to create snags where natural snags are lacking.

The intent of measures (16) through (18) is to provide a variety of wildlife and suitable habitat. Effectiveness is based on principles of wildlife management and habitat requirements as described in FSH 2609.23R, FSH 2609.13, and general wildlife management texts such as Peek (1986). Monitoring is accomplished through review of project proposals, onsite inspections, and periodic inventories.

#### h. Corridors

(19) Each forest works with utility special-use permittees to establish vegetation management objectives (such as wildlife, watershed, recreation, visual quality) for location of new utility lines and maintenance of existing ones. These objectives determine maintenance techniques and strategies.

(20) Where feasible, low-growing shrubs and grasses are established and maintained along utility lines where wildlife and aesthetic objectives are dominant. This measure applies only to alternatives B, C, D, E, G, and Modified G.

(21) Permanent vegetation is established and maintained on intermittent service roads when they are closed and on cut and fill slopes of all roads.

(22) Where practical, native flowering species are established, maintained, and enhanced on intermittent service roads when they are closed and on cut and fill slopes of all roads. This measure applies only to alternatives B, C, D, E, G, and Modified G.

(23) Vegetation along trails is treated to maintenance levels identified in the publication "Trails South." Priority is given to correcting unsafe conditions, preventing resource damage, and providing for intended recreation experience level.



Measures (19) through (23) balance considerations for special uses and other forest values, promote safe and efficient use of facilities and limit adverse visual and erosion effects. Experience shows that careful coordination between resources and special uses effectively allows compatible, concurrent use. Monitoring is done through project proposal reviews, periodic inspections, and maintenance plan reviews.

**i. Range Forage**

(24) When managing for range forage species, wildlife and livestock use should not exceed 50 percent of current annual growth of key grass species, 20 percent of total annual production of key forb species, and 20 percent of current annual growth of key shrub species.

This requirement protects range forage from overuse and decline. Years of management experience and field inventories of range species have determined optimum use levels. Monitoring is done through allotment management reviews and periodic inventories.

**2. Method-Specific Management Requirements and Mitigation Measures**

These requirements and measures are in addition to general requirements and measures in the preceding section.

**a. Prescribed Fire**

The following apply to alternatives that use prescribed fire. **Each forest may be more restrictive but not less.**

(1) Site-specific planning for all prescribed burns is done by trained resource specialists and approved by the appropriate Forest Service line officer prior to project implementation. This planning includes description of treatment area, burn objectives, weather factors and fuel moisture conditions, and resource coordination requirements. Coordination requirements include provisions for public and worker safety, burn day notification of appropriate agencies and persons, smoke management to comply with air quality regulations and protect visibility in Class I areas, protection of sensitive features, as well as fireline placement, specific firing patterns, ignition methods, and mop-up and patrol procedures. A post-burn evaluation compares treatment results with plan objectives.

This requirement ensures thorough planning, well-defined objectives, and selection of appropriate mitigation measures. Experience shows that planning and evaluation effectively eliminate avoidable adverse effects. Monitoring is done through review of burn plans, onsite inspections, and post-burn evaluations.

Vegetation  
Protection

(2) Prescribed fires in loblolly, shortleaf, slash, and sand pine stands are not done until pines are 10 to 15 feet tall or 3 to 4 inches in diameter at ground level. In longleaf pine stands, burns can be used prior to height growth for brownspot disease control when root collars of grass stage seedlings are at least 0.3 to 0.5 inch in diameter. After height growth begins, burns can be used once seedlings are 3 to 5 feet tall.

This measure protects trees from damage by fire. Goebel, Brender, and Cooper (1967), Chen, Hodgkins, and Watson (1975), Johnson (1982), Komarek (1974), and Wade (1986) show its effectiveness in limiting injury and mortality. Monitoring is done in project proposal reviews and post-burn evaluations.

Soil and Water  
Protection

(3) Slash burns are done so they do not consume all litter and duff and alter structure and color of mineral soil on more than 20 percent of the area. This measure applies only to alternatives B, C, D, E, G, and Modified G. Steps taken to limit soil heating include use of backing fires on steep slopes, scattering slash piles, and burning heavy fuel pockets separately.

(4) On severely eroded forest soils, any area with an average litter-duff depth of less than 1/2 inch is not burned. This measure applies only to alternatives B, C, D, E, G, and Modified G.

(5) Growing season underburns are not allowed on the same site more than twice in succession without an intervening dormant season burn. This measure applies only to alternatives B, C, D, E, G, and Modified G.

Measures (3) through (5) protect soil productivity. Appendix B and the analysis in chapter IV found these measures effective in preventing excessive losses of soil biota, organic matter, and nutrients. Monitoring includes project proposal reviews and post-burn evaluations.

(6) Where needed to prevent erosion, water diversions are installed on firelines during their construction, and the firelines are revegetated promptly after the burn.

(7) Firelines which expose mineral soil are not located in filter strips along lakes, perennial or intermittent springs and streams, wetlands, or water-source seeps, unless tying into lakes or streams as firebreaks at designated points with minimal soil disturbance. Low-intensity fires with less than 2-foot flame lengths may be allowed to back into the strip, as long as they do not kill trees and shrubs that shade the stream. The strip's width in feet is at least 30 plus 1.5 times the percent slope.



Measures (6) and (7) limit erosion and siltation. Cushwa, Hopkins, and McGinnes (1971) found that prevention of fireline erosion effectively eliminates sedimentation from many burns. Swift (1986) showed the above filter strip to be effective in trapping soil eroded by unconcentrated surface runoff. Monitoring is done in project proposal reviews, during burns, and in post-burn evaluations.

#### Wetland Protection

(8) When wetlands need to be protected from fire, firelines are plowed around them only when the water table is so low that the prescribed fire might otherwise damage wetland vegetation or organic matter. Previous firelines are reused as much as possible.

(9) If a fireline is required next to a wetland, it is not plowed in the transition zone between upland and wetland vegetation except to tie into a natural firebreak.

(10) Plowed firelines are not located within savannahs except when needed to protect facilities or threatened, endangered, proposed, or sensitive species.

The purpose of measures (8) through (10) is to prevent fireline scars which are often slow to heal in wetlands and savannahs. Additionally, hydraulic integrity of wetlands is protected. Monitoring is accomplished through project proposal reviews and post-burn evaluations.

#### Air Quality Protection

(11) The best available technology to control smoke emissions is used, including accelerated mop-up, rapid ignition techniques, and burning when moisture conditions limit total smoke production. Burning is not done during stagnant weather nor when predictions indicate that smoke drift into highways, airports, populated areas, or other sensitive areas may be hazardous.

The intent of this measure is to comply with air quality regulations and protect health and safety. USDA Forest Service (1976) and Sandburg and Ward (1981) demonstrate that these measures are effective in limiting smoke emissions and their effects. Monitoring includes review of project plans, pre-burn weather evaluations, and during-burn inspections.

#### Wildlife and Habitat Protection

(12) Oak, oak-gum-cypress, and oak-pine stands and inclusions are protected by excluding fire or by using low-intensity backing fires.

(13) Generally, understory burns are not scheduled during nesting season to avoid disrupting reproductive activities. Forest managers may, however, use burns to meet specific objectives, such as protecting threatened and endangered species (e.g., red-cockaded woodpecker), reestablishing natural ecosystems, controlling brownspot disease and

promoting longleaf height growth, and site preparation. Burns are planned and executed to avoid damage to habitat of any threatened, endangered, proposed, or sensitive species (such as destruction of bald eagle nest trees).



(14) Burns are planned to achieve their most desirable distribution for wildlife habitat and to try to break up large, continuous fuel types. When consistent with burning objectives, burns are done to create a mosaic pattern of fuel types that complements fuel treatment and wildlife objectives. This measure applies only to alternatives B, C, D, E, G, and Modified G.

Measures (12) through (14) protect valued habitats, minimize disruption of reproduction, and promote habitat variety. Effectiveness is based on principles of wildlife management and habitat requirements as described in FSH 2609.23R, FSH 2609.13, and general wildlife management texts such as Peek (1986). Monitoring occurs in project plan reviews and post-burn evaluations.

#### Safety

(15) Prescribed fires are conducted under the direct supervision of a burning boss with fire behavior expertise consistent with the project's complexity. All workers must meet health, age, physical and training requirements in FSM 5140, and use protective clothing and equipment.

This measure protects worker and public safety during prescribed burning. Monitoring occurs in project proposal reviews, onsite inspections, and post-burn evaluations.

#### b. Mechanical Method

The following apply to alternatives that use mechanical methods. **Each forest may be more restrictive but not less.**

Soil and Water  
Protection

- (1) Prompt revegetation is done if treatments leave insufficient ground cover to control erosion by the end of the first growing season.
- (2) Only mowing, chopping, shearing, ripping, and scarifying are used on sustained slopes over 15 percent. No mechanical equipment is used on sustained slopes over 35 percent.
- (3) Mechanical site preparation is not done on sustained slopes over 20 percent with erodible or failure-prone soils.
- (4) To limit soil compaction, no mechanical equipment is used on plastic soils when the water table is within 12 inches of the surface, or when soil moisture exceeds the plastic limit. Soil moisture exceeds the plastic limit if the soil can be rolled to pencil size without breaking or crumbling.
- (5) Mechanical equipment is operated so that furrows and soil indentations are aligned on the contour (with grades under 5 percent).
- (6) Bedding is done only on level, wet sites, and only when needed to ensure survival and growth of managed trees. Beds must have an initial height no greater than 15 inches and blend with the natural landform.
- (7) Windrows and piles are spaced no more than 200 feet apart to limit soil exposure, soil compaction, and nutrient loss from piling and raking. Windrows are aligned on the contour.
- (8) When piling, at least 80 percent of the area must retain some ground cover of litter and duff, and soil must not be displaced by piling rakes.





(9) Mechanical equipment is not allowed in any defined stream channel except to cross at designated points, and may not expose more than 10 percent mineral soil in filter strips along lakes, perennial or intermittent springs and streams, wetlands, or water-source seeps. The strip's width in feet is at least 30 plus 1.5 times the percent slope. Soil and debris are not deposited in lakes, streams, wetlands, springs, or seeps.

Measures (1) through (9) minimize soil damage and sedimentation. Beasley, Granillo, and Zillmer (1986), Blackburn, Wood, and DeHaven (1986), Gent, Ballard, and Hassan (1983), Gent and others (1984), and Swift (1986) found these measures to be effective and necessary to control soil damage and loss. Monitoring is done in project plan reviews and post-project evaluations.

#### Corridors

(10) All trails, roads, ditches, and other improvements in the project area are kept free of logs, slash, and debris. Any road, trail, ditch, or other improvement damaged by operations is promptly repaired.

This measure protects improvements. Experience shows that preventive measures or prompt repair effectively minimizes damages. Monitoring is done in project plan reviews and post-project evaluations.

#### Safety

(11) Equipment operators must demonstrate proficiency with the equipment and be licensed to operate it. A helper must direct the operator where safety is compromised by terrain or limited sight distance.

The intent of this measure is to protect worker and public safety. Monitoring occurs in periodic inspections and licensing.

#### c. Herbicide Method

The following apply to alternatives that use herbicides. **Each forest may be more restrictive but not less.**

(1) Herbicides are applied according to labeling information and the site-specific analysis done for projects. This labeling and analysis are used to choose the herbicide, rate, and application method for the site. They are also used to select measures to protect human and wildlife health, non-target vegetation, water, soil, and threatened, endangered, proposed, and sensitive species. Site conditions may require stricter constraints than those on the label, but labeling standards are never relaxed.

#### Choice of Herbicide

(2) Only herbicide formulations (active and inert ingredients) and additives registered by EPA and approved by the Forest Service are applied.

(3) Herbicides and application methods are chosen to minimize risk to human and wildlife health and the environment. This measure applies only to alternatives B, C, E, G, and Modified G. The following criteria apply to information in table II-1:

Class A herbicide/method combinations are first choice.

Class B combinations are used only if no Class A herbicide can meet project objectives, and then only if adverse effects are mitigated to acceptable levels.

Class C combinations are used only if no Class A or B herbicide can meet project objectives, and then only if adverse effects are mitigated to acceptable levels.

Class D combinations are never used.

#### Application Rate

(4) Herbicides are applied at the lowest rate effective in meeting project objectives and according to guidelines for protecting human (NRC 1983) and wildlife health (EPA 1986a). Application rate and work time must not exceed typical levels (appendix A, tables 4-4 to 4-6) unless a supplementary risk assessment shows that proposed rates do not increase risk to human or wildlife health or the environment beyond standards discussed in Chapter IV. This measure applies only to alternatives B, C, E, G, and Modified G. Typical application rates (lb/ac) of active ingredient are:



	2,4-D/a	2,4-D/e	2,4-DP	DICAMBA	FOSAMINE	GLYPHOS	HEXAZ	IMAZAPYR
AL	2.0	2.5	3.0		10.0	1.5	1.5	0.75
AG							1.7	
ML	2.5	4.0	4.0	2.0	7.8	1.5	1.7	0.75
MG							1.7	
HG							1.7	
HF	2.0	2.0	1.0	2.0		1.0	1.7	0.75
HB		1.7	1.2					
HS							0.5	
HC	2.0			1.5		1.3		0.75

	FUEL OIL	LIMONENE	PICLORAM	SULFOMET	TEBUT	TRICLOPYR/a	TRICLOPYR/e
AL	0.5	0.9	0.5	0.13	1.0	3.0	4.0
AG					1.0		
ML	2.0	0.9	0.7	0.17	1.0	4.0	4.0
MG					1.0		
HG							
HF	1.5	0.9	0.4	0.06	4.0	1.4	1.0
HB	1.0	0.9					1.9
HS					4.0		
HC			0.3				

KEY: AL = aerial liquid treatment      GLYPHOS = glyphosate  
AG = aerial granular treatment      HEXAZ = hexazinone  
ML = mechanical liquid treatment      SULFOMET = sulfometuron methyl  
MG = mechanical granular treatment      TEBUT = tebuthiuron  
HG = manual (hand) granular treatment      /a = amine formulation  
HF = manual foliar broadcast treatment      /e = ester formulation  
HB = manual basal treatment  
HS = manual soil-spot treatment  
HC = manual cut-surface treatment

Application Method (5) Method and timing of application are chosen to achieve project objectives while miniizing effects on non-target vegetation and other environmental elements. Selective treatment is preferred over broadcast treatment. Public safety during such uses as viewing, hiking, berry picking, and fuelwood gathering is a priority concern. This measure applies only to alternatives B, C, E, G, and Modified G. Application methods from most to least selective are:

- 1) Cut surface treatments
- 2) Basal stem treatments
- 3) Directed foliar treatments
- 4) Soil spot (spot around) treatments



- 5) Soil spot (spot grid) treatments
- 6) Manual granular treatments
- 7) Manual/mechanical broadcast treatments
- 8) Helicopter treatments

Prescribed Burning  
of Treated Areas

(6) Areas are not prescribed burned for at least 30 days after herbicide treatment. This measure applies only to alternatives B, C, E, G, and Modified G.

Measures (1) through (6) ensure legal compliance and mandate further steps to improve safety and effectiveness of treatment. The Risk Assessment (appendix A) shows that screening herbicides, reducing application rates, and using selective application methods lowers health and environmental risk. Experience has shown 30 days to be the minimum time for herbicides to work and fuels to cure. Monitoring is done by reviewing purchase orders, project reports, and annual herbicide-use reports.

Drift Control

(7) Weather is monitored and the project is suspended if temperature, humidity, or wind become unfavorable as follows:

	<u>Temperatures Higher Than</u>	<u>Humidity Less Than</u>	<u>Wind (at Target) Greater Than</u>
Ground:			
Hand (cut surface)	N.A.	N.A.	N.A.
Hand (other)	98F	20%	15 mph
Mechanical (liquid)	95F	30%	10 mph
Mechanical (granular)	N.A.	N.A.	10 mph
Aerial: Liquid	90F	50%	5 mph
Granular	N.A.	N.A.	8 mph



(8) Nozzles that produce large droplets or streams of herbicide are used. Nozzles that produce fine droplets are used only for hand treatment where distance from nozzle to target does not exceed 8 feet.

Measures (7) and (8) reduce drift of herbicides offsite. Yates, Akisson, and Bayer (1978) demonstrated their effectiveness. Monitoring occurs via weather observation and supervision.

#### Supervision and Training

(9) A certified pesticide applicator supervises each Forest Service application crew and trains crew members in personal safety, proper handling and application of herbicides, and proper disposal of empty containers.

(10) Each Contracting Officer's Representative (COR), who must ensure compliance on contracted herbicide projects, is a certified pesticide applicator. Contract inspectors are trained in herbicide use, handling, and application.

Measures (9) and (10) promote compliance with labeling instructions and reduce risk of accidents. Effectiveness and monitoring are provided by the Pesticide Applicators Training and Certification program, where a minimum test score of 70 percent is required for certification.

#### Protection of Workers

(11) Forest Service workers who handle herbicides must wear a long-sleeved shirt and long pants made of tightly woven cloth that must be cleaned daily. They must wear a hard hat with plastic liner, waterproofed boots and gloves, and other safety clothing and equipment required by labeling. They must bring a change of clothes to the field in case their clothes become contaminated.

(12) Each Forest Service crew must take soap, wash water separate from drinking water, eyewash bottles, and first aid equipment to the field.

(13) Contractors ensure that their workers use proper protective clothing and safety equipment required by labeling for the herbicide and application method. This measure applies only to alternatives B, C, E, G, and Modified G.

(14) Workers must not walk through areas treated by broadcast foliar methods on the day of application. This measure applies only to alternatives B, C, E, G, and Modified G.

(15) Supervisors must ensure that monitoring is adequate to prevent adverse health effects. Workers displaying unusual sensitivity to the herbicide in use are medically evaluated and, if tested as sensitive to the herbicide in use, are reassigned to other activities.

Measures (11) through (15) reduce worker exposure to herbicides. Lavy, Mattice, and Norris (1984), Webster and Maibach (1985), and Yi-Lan and others (1984) demonstrate their effectiveness. Monitoring is done through supervision and review of accident reports.

Protection of  
the General Public  
and Private Land

(16) Notice signs (FSH 7109.11) are clearly posted, with special care taken in areas of anticipated visitor use. People living within one-fourth mile of an area to be treated aerially are notified during project planning and shortly before treatment.

(17) No herbicide is broadcast within 100 feet of private land or 300 feet of a private residence, unless the landowner agrees to closer treatment. Buffers are clearly marked before treatment so applicators can easily see and avoid them. This measure applies only to alternatives B, C, E, G, and Modified G.

Measures (16) and (17) reduce public exposure to herbicides. Monitoring occurs during project plan reviews, onsite inspections, and post-project evaluations.

Protection of  
Non-Target  
Vegetation

(18) No soil-active herbicide is applied within 30 feet of the drip line of non-target vegetation (e.g., den trees, hardwood inclusions, adjacent stands) within or next to the treated area. Side pruning is allowed, but movement of herbicide to the root systems of non-target plants must be avoided. Buffers are clearly marked before treatment so applicators can easily see and avoid them. This measure applies only to alternatives B, C, E, G, and Modified G.

This measure protects non-target plants in and next to treated areas. Appendices A and C show that buffers sharply reduce offsite movement. Monitoring occurs through project plan reviews, onsite inspections, and post-project evaluations.

Protection of  
Threatened,  
Endangered,  
Proposed, and  
Sensitive Species

(19) 2,4-D, 2,4-DP, and triclopyr are not aerially applied within 300 feet, nor ground-applied within 60 feet, of occupied gray or Indiana bat habitat. The same buffers are used with 2,4-D and 2,4-DP around habitat of the endangered Florida scrub jay, and with 2,4-D around habitat of these sensitive animals: star-nosed mole, Florida mouse, old-field mouse, masked shrew, southeastern shrew, southern pygmy shrew, long-tail shrew, southern water shrew, southern rock vole, and red-backed vole. The same buffers are used with any formulation containing kerosene or diesel oil around habitat of any threatened, endangered, proposed, or sensitive bird during its nesting season. Buffers are clearly marked before treatment so applicators can easily see and avoid them.



(20) No herbicide is aerially applied within 300 feet, nor ground-applied within 60 feet, of any threatened, endangered, proposed, or sensitive plant. Buffers are clearly marked before treatment so applicators can easily see and avoid them.

Measures (19) and (20) protect these species from toxic effects as predicted by the Risk Assessment (appendix A). They are consistent with EPA's proposed restrictions on use of certain herbicides. If EPA requires stricter standards for any herbicide in the future, the Forest Service will adopt them. Monitoring occurs through project plan reviews, onsite inspections, and post-project evaluations.

#### Protection of Water and Soil

(21) Application equipment, empty herbicide containers, clothes worn during treatment, and skin are not cleaned in open water or wells. Mixing and cleaning water must come from a public water supply and be transported in separate labeled containers.

(22) Aquifers and public water sources are identified and protected. States are consulted to ensure compliance with their ground water protection strategies.

(23) No herbicide is broadcast on rock outcrops or sinkholes. No soil-active herbicide with a half-life longer than 3 months is broadcast on slopes over 45 percent, erodible soils, or aquifer recharge zones. Such areas are clearly marked before treatment so applicators can easily see and avoid them.

(24) No herbicide is aerially applied within 100 horizontal feet, nor ground-applied within 30 horizontal feet, of lakes, wetlands, or perennial or intermittent springs and streams. No herbicide is applied within 100 horizontal feet of any public or domestic water source. Selective treatments (which require added site-specific analysis and use of aquatic-labeled herbicides) may occur within these buffers only to prevent significant environmental damage such as noxious weed infestations. Buffers are clearly marked before treatment so applicators can easily see and avoid them.

Measures (21) through (24) reduce risk of surface and ground water pollution and soil erosion. Appendices A and C show that buffers sharply reduce offsite herbicide movement. Monitoring is done through project plan reviews, onsite inspections, and post-project evaluations.

#### Aerial Application Operations Plan

(25) Each aerial herbicide application project must have an operations plan approved by the forest's air safety officer who must ensure that: (a) adequate precautions are taken to

protect the crew, including equipment certification and hazard identification; (b) areas to be aerially treated are clearly marked; and (c) methods used to avoid buffers and other sensitive areas are safe and effective. This measure applies only to alternatives G, Modified, G, and H.

This measure provides for crew safety and protection of non-target areas. Monitoring occurs through project plan reviews, onsite inspections, and post-project evaluations.

#### Control of Spills

(26) During transport, herbicides, additives, and application equipment are secured to prevent tipping or excess jarring and are carried in a part of the vehicle totally isolated from people, food, clothing, and livestock feed.

(27) Only the amount of herbicide needed for the day's use is brought to the site. At day's end, all leftover herbicide is returned to storage.

(28) Herbicide mixing, loading, or cleaning areas in the field are not located within 200 feet of private land, open water or wells, or other sensitive areas.

(29) During use, equipment to store, transport, mix, or apply herbicides is inspected daily for leaks.

(30) Containers are reused only for their designated purpose. Empty herbicide containers are disposed of according to 40 CFR 165.9 Group I & II Containers.

(31) Accident preplanning is done in each site-specific analysis. Emergency spill plans (FSM 2109.12, chapter 30) are prepared. In the unlikely event of a spill, the spill is quickly contained and cleaned up, and appropriate agencies and persons are promptly notified.

Measures (26) through (31) reduce risk of accidental contamination of humans or the environment by concentrated amounts of herbicide. Experience has shown them to be effective in reducing spillage and contamination. Monitoring occurs through supervision and incident report reviews.

#### d. Biological Method

The following apply to alternatives that use grazing as a biological method for pine release. **Each forest may be more restrictive but not less.**

(1) A site-specific analysis determines how livestock are managed to limit soil compaction, water contamination, and damage to riparian vegetation and streambanks.

(2) To protect seedlings, grazing as a biological method is excluded from:

(a) longleaf pine stands until seedlings are out of the grass stage and starting height growth;

(b) other pine stands less than age 3 years; and

(c) hardwood stands for at least 5 years after stand establishment.

(3) Trampling damage or browsing of the terminal leaders of desired trees should not exceed 5 percent.

Measures (1) through (3) protect site values such as soil, water, and desirable vegetation when grazing is used as a biological control. Blackburn (1984) and Patric and Helvey (1986) showed that such controls reduce grazing damage to soil and water. Monitoring is done through project plan reviews and periodic on-site evaluations.

e. Manual Method

The following applies to alternatives that use manual methods. **Each forest may be more restrictive but not less.**

Safety

(1) Chain saw operators must be periodically certified and demonstrate proficiency with chain saws.

(2) Forest Service workers must comply with dress and safety standards specified in the Health and Safety Code Handbook (FSH 6709.11).

The intent of measures (1) and (2) is to protect worker and public safety. Monitoring occurs in periodic inspections and recertification.

**F. COMPARISON OF  
ALTERNATIVES WITH THE  
ISSUES**

Issues (chapter I) express concerns of the public and Forest Service employees, including management. These issues are the foundation for alternatives discussed earlier in this chapter. In this section, we compare the alternatives to see how they respond to the issues (table II-3).

Issues contain many values and are neither positive nor negative. Actually, issues express multiple concerns and desires, many of which are opposed to each other. Because of this aspect of issues, every alternative responds to each issue to some degree.

Major changes are expected when each alternative is compared with alternative A, the "no action" alternative (table II-3). Each issue is paraphrased in the following text, and the measure of comparison used in table II-3 is stated.



Table II-3.—Comparison of alternatives with issues

ALTERNATIVE	ISSUES				
	Balance of Resources	Prescribed Fire	Health & Safety	Plant & Animal Diversity	Cost Comparison
Comparison Measure	Output mix.	Availability, timing, intensity.	Risk level.	Method selectivity.	Per acre costs, employment.
<b>A</b> (No Action)	Strongly favors non-market outputs due to no vegetation manipulation.	Not available for use.	Eliminates direct risk, increases risk on travelways and from wildfire.	No methods used.	Direct costs and employment opportunity eliminated.
<b>B</b>	Favors non-market outputs, holds market to custodial level.	Very limited availability, low intensity. Timing restricted.	Minimizes direct risk, increases risks from wildfire.	Few acres treated, methods highly selective.	Direct costs and employment opportunity very low.
<b>C</b>	Favors non-market less than B but more than F.	Less available than F, low intensity. Timing somewhat restricted.	Decreases herbicide and mechanical risks, slight increase for manual.	Fewer acres treated, methods more selective than F.	Per acre costs lowest, employment lower than F.
<b>D</b>	Market outputs same as F, non-market outputs increase slightly.	As available as F, low to moderate intensity. Timing not restricted.	Herbicide risks eliminated, manual and mechanical increase.	Increase of less selective mechanical and more selective manual.	Cost comparable to F, employment higher.
<b>E</b>	Non-market outputs increase, market outputs lower or at higher cost.	More available than F, low to moderate intensity. Timing not restricted.	Risks from use of fire and manual increase, herbicide risks decreased.	Increase of more selective manual, slight increase in fire use.	Per acre costs comparable to C, employment highest.
<b>F</b> (Current)	Favors market outputs.	Low, moderate, and high intensity. Timing not restricted.	Risks not minimized, high for manual.	Non-selective methods widely available.	Costs are highest, employment moderate.
<b>G</b> (Draft Preferred)	Market outputs same as F, non-market outputs increase slightly.	More available than F, low to moderate intensity. Timing not restricted.	Number of exposed persons increases, risk per person declines. Mechanical risks decline.	Mechanical reduced, herbicides increased, manual slightly increased.	Cost lower than F, employment unchanged.
<b>MODIFIED G</b> (Final Preferred)	Market outputs same as F, non-market outputs increase.	More available than F, low to moderate intensity. Timing not restricted.	Persons exposed greater than F, risk per person less. Mechanical risks decline.	Mechanical reduced; herbicides, manual, selectivity increased.	Cost lower than F, employment unchanged.
<b>H</b>	Strongly favors market, decreases non-market outputs.	Most available, increased intensity. Timing not restricted.	All risks increase except manual which decreases.	Substantially increases the use of non-selective methods and tools.	Costs somewhat lower, employment opportunity increases.

ISSUES				
Soil Productivity	Water Quality	Herbicides	Aerial Application	Wildlife
Treatment intensity.	Risk to water uses.	Tool selectivity, risk.	Availability.	Habitat quality.
No treatments.	No treatments, no risks.	No treatments, no risk.	Not available. improve quality.	No treatments to
Very low intensity.	Minimum treatments, very low risk.	Lowest risk when used, highly selective application tools.	Not available.	No treatments to improve quality, minimum T&E maintenance.
Low intensity.	Risks lower than F from all methods.	Lower risk than F, highly selective tools.	Not available.	Habitat treatments allowed only to maintain populations.
More mechanical treatments, but lower intensity.	Herbicide risk eliminated, other risks lower than F.	No treatments, no risk.	Not available.	Comparable to F, but herbicides not available for habitat treatment.
Fire treatments increase, mechanical decreases, lower intensity.	Herbicide and other risks lower than F.	Much lower risk than F, broadcast application allowed.	Not available.	Comparable to F with decreased use of mechanical treatment.
High intensity methods available.	Moderate risk, mostly mechanical.	Broadcast and selective used.	Not used, deferred.	High intensity methods degrade some habitat.
Fire and herbicide increase, lower intensity than F.	Herbicide risk higher than F, other risks lower.	Use of broadcast leads to less target selectivity.	7,000 acres available.	Reduced mechanical, greater flexibility to protect or improve habitat.
Fire and herbicide increase, lower intensity than F.	Herbicide risk between F and G, other risks lower.	More herbicide use than F, but selectivity increases.	2,500 acres available.	Reduced mechanical, greater flexibility and selectivity than F.
Substantially increased use of high intensity methods.	All risks substantially higher than F.	Highest risk, broadcast application including aerial allowed.	28,000 acres available.	High intensity methods may degrade habitat, improvement work increases.

Balance of resources: Concern is about the mix of resource outputs from forests and grasslands. It is believed that an increase in market outputs like timber or an increase in non-market outputs like aesthetics would necessarily be at the expense of the other. The measure of comparison is change in output mix.

Prescribed fire: Such treatments are generally seen as a "natural" process and as necessary for some ecosystems as well as for protection from wildfires. Concern centers on season, frequency, and intensity of use. Comparison measures are availability of fire for fuel and habitat treatments and restrictions on timing and intensity.

Health and safety: Concern is that risk of accidents and illness should be evaluated and then minimized for workers, users, and neighbors. Comparison is risk level.

Plant and animal diversity: This concern focuses on potential loss of a species from a site, but an associated concern is effect on hardwoods. Measure of comparison is selectivity of methods used.

Communication: This unique issue has only an indirect relationship to vegetation management. Responsiveness to this issue does not depend on alternatives, so it is not in the comparison table. This EIS is an educational tool, and in part addresses communication by discussing the types and effects of vegetation management. Public participation has been vital to this EIS, which mandates that it be continued in the future.

Cost comparison: A mixture of concerns exists about using least-cost methods as well as being sensitive to employment opportunities. Measures of comparison are per-acre treatment costs and employment opportunity.

Soil productivity: People are concerned about erosion, compaction, rutting, and loss of soil organisms. The most direct cause-effect relationship is with intensity of methods which may cause these effects, so the comparison measure is treatment intensity.

Water quality: Concerns are about potential negative effects on beneficial uses of water. Comparison is based on level of risk to such uses.

Herbicides: One concern is that non-target organisms might be affected, and the other is that there are risks to human health. The measures of comparison are selectivity of treatment tools and level of risk.



Aerial application: Aerial application of herbicides has clearly defined and opposite concerns. One set of interests is concerned that aerially applied herbicides are not selective and will affect many non-targets. Other interests believe that aerial application is an essential tool for economical treatment of some areas. Measure of comparison is availability of aerial application.

Wildlife: Concerns center on wildlife habitat for game, non-game, and threatened and endangered species. One facet of these concerns is potential negative effects caused by the use of any method. An equally important facet is managing vegetation to enhance or create more wildlife habitat. The measure of comparison is habitat quality.

#### **G. COMPARISON OF ENVIRONMENTAL EFFECTS**

Every alternative has the potential to cause environmental effects. Environmental effects are analyzed in chapter IV. Ways to limit or control these effects are the management requirements and mitigation measures discussed earlier in this chapter. Because each alternative represents a different way to accomplish vegetation management work, effects also differ.

##### **Makeup of Alternatives**

Kinds of effects and their severity are determined by several factors:

- Which methods and tools are used?
- How many acres are treated?
- What intensity and frequency of treatments are applied?

Before reading the evaluation of environmental effects in chapter IV or looking at the comparison of effects between alternatives in table II-8, readers should become familiar with how these factors vary between alternatives. If the factors are understood, then the type and severity of effect can be better understood.

Table II-4 displays methods and tools available for use in each alternative. Each alternative has a unique set of methods and tools. For example, herbicides are not available in alternative D; biological methods are not available in alternatives B, F, and Modified G; aerial herbicide application is available at varying levels only in alternatives G, Modified G, and H; and raking is only available in alternatives F and H. Careful review will find many other differences.

Table II-5 shows the number of acres treated with each method in each alternative, and lists total acres treated.

Table II-4.—Comparison of methods and tools by alternative

A (No Action)	B	C	D	E
None	<u>Herbicides</u> Hand ground tools Backpack sprayer Spotguns Hypo-hatchets Injectors Axe & sprayer	<u>Herbicides</u> Hand ground tools Backpack sprayer Spotguns Hypo-hatchets Injectors Axe & sprayer	<u>Herbicides</u> None	<u>Herbicides</u> Mechanical ground tools Boom sprayer Granular spreader Hand ground tools Backpack sprayers Spotguns Hypo-hatchet Injectors Axe & sprayer
None	<u>Mechanical</u> Low soil disturbance Mowing	<u>Mechanical</u> Low soil disturbance Mowing Chopping Shearing Ripping Scarifying	<u>Mechanical</u> Low to mod. soil disturbance Mowing Chopping Shearing Ripping Scarifying Piling Bedding Light disking	<u>Mechanical</u> Low to mod. soil disturbance Mowing Chopping Shearing Ripping Scarifying Piling Bedding Light disking
None	<u>Manual</u> Moderate amounts Power tools Hand tools	<u>Manual</u> Moderate amounts Power tools Hand tools	<u>Manual</u> Moderate amounts Power tools Hand tools	<u>Manual</u> Moderate to high amounts Power tools Hand tools
None	<u>Fire</u> Low intensity Dormant season burns Aerial tools Ground tools	<u>Fire</u> Low intensity Dormant and growing season burns Aerial tools Ground tools	<u>Fire</u> Low to moderate intensity Dormant and growing season burns Aerial tools Ground tools	<u>Fire</u> Low to moderate intensity Dormant and growing season burns Aerial tools Ground tools
None	<u>Biological</u> None	<u>Biological</u> Minor Livestock	<u>Biological</u> Low increase Livestock	<u>Biological</u> Low increase Livestock

<u>F</u> (Current)	G (Draft Preferred)	Modified <u>G</u> (Final Preferred)	<u>H</u>
<u>Herbicides</u>	<u>Herbicides</u>	<u>Herbicides</u>	<u>Herbicides</u>
Mechanical ground tools	Aerial tools	Aerial tools	Aerial tools
Boom Sprayer	Helicopter	Helicopter	Helicopter
Granular spreader	Mechanical ground tools	Mechanical ground tools	Mechanical ground tools
Hand ground tools	Boom sprayer	Boom sprayer	Boom sprayer
Backpack sprayers	Granular spreader	Granular spreader	Granular spreader
Spotguns	Hand ground tools	Hand ground tools	Hand ground tools
Hypo-hatchet	Backpack sprayers	Backpack sprayers	Backpack sprayers
Injectors	Spotguns	Spotguns	Spotguns
Axe & sprayer	Hypo-hatchets	Hypo-hatchets	Hypo-hatchets
	Injectors	Injectors	Injectors
	Axe & sprayer	Axe & sprayer	Axe & sprayer
<u>Mechanical</u>	<u>Mechanical</u>	<u>Mechanical</u>	<u>Mechanical</u>
Low to high soil disturbance	Low to mod. soil disturbance	Low to mod. soil disturbance	Low to high soil disturbance
Mowing	Mowing	Mowing	Chopping
Chopping	Mowing	Mowing	Chopping
Shearing	Shearing	Shearing	Shearing
Ripping	Ripping	Ripping	Ripping
Scarifying	Scarifying	Scarifying	Scarifying
Piling	Piling	Piling	Piling
Bedding	Bedding	Bedding	Bedding
Raking	Light disking	Light disking	Raking
Light disking			Light disking
Heavy disking			Heavy disking
<u>Manual</u>	<u>Manual</u>	<u>Manual</u>	<u>Manual</u>
Low to moderate amounts	Low amounts	Low amounts	Low amounts
Power tools	Power tools	Power tools	Power tools
Hand tools	Hand tools	Hand tools	Hand tools
<u>Fire</u>	<u>Fire</u>	<u>Fire</u>	<u>Fire</u>
Low to high intensity	Low to moderate intensity	Low to moderate intensity	Low to high intensity
Dormant and growing season burns	Dormant and growing season burns	Dormant and growing season burns	Dormant and growing season burns
Aerial tools	Aerial tools	Aerial tools	Aerial tools
Ground tools	Ground tools	Ground tools	Ground tools
<u>Biological</u>	<u>Biological</u>	<u>Biological</u>	<u>Biological</u>
None	Low increase	None	Maximum
	Livestock		



Table II-5.--Comparison of acres treated by alternative

<u>Method</u>	<u>Alternative</u>								<u>H</u>
	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>	<u>F</u>	<u>G</u>	Mod. <u>G</u>	
Herbicide	0	3,379	17,117	0	11,328	26,793	49,312	39,529	65,385
Mechanical	0	12,332	35,458	71,097	35,916	59,231	32,247	41,582	64,258
Fire	0	113,573	354,934	464,284	472,529	463,076	467,038	467,038	667,074
Manual	0	956	6,299	18,042	33,650	4,376	4,823	5,327	1,221
Biological	0	0	16	53	53	0	53	0	3,053
Total	0	130,240	413,824	553,476	553,476	553,476	553,476	553,476	801,991
% Treated*	0	2.8	9.0	12.0	12.0	12	12.0	12.0	17.4

\*Portion of total 4.6 million acres treated annually.

Table II-6 expresses the data from table II-5 as percentages to more clearly show how use of each method varies by alternative. Table II-7 lists frequency of recurring treatments in each alternative.

Prescribed fire makes up a large majority of treatments. Use of other methods varies substantially between alternatives. Tables II-5 and II-6 should be used together, because total acres treated by all methods vary. Note that in alternative B, about 2.6 percent of the acres treated are done

Table II-6.--Comparison of method mix (% acres treated) within alternatives

<u>Method</u>	<u>Alternative</u>								<u>H</u>
	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>	<u>F</u>	<u>G</u>	Mod. <u>G</u>	
Herbicide	0	2.6	4.1	0	2.0	4.9	8.9	7.1	8.2
Mechanical	0	9.5	8.6	12.8	6.5	10.7	5.8	7.5	8.0
Fire	0	87.2	85.8	83.9	85.4	83.6	84.4	84.4	83.3
Manual	0	0.7	1.5	3.3	6.1	0.8	0.9	1.0	0.1
Biological	0	0	0.0	0.0	0.0	0	0.0	0	0.4

Table II-7.--Average treatment frequencies (years) by alternative

Treatment of:	A	B	C	D,E,F,G,Mod. G	H
Hazard fuels-Coastal Plain	None	5	5	4	3
-Piedmont	None	7	7	6	5
Threatened & Endangered Species Habitat	None	3	2	2	2
Other Wildlife Habitat					
-Coastal Plain	None	None	5	4	3
-Piedmont	None	None	7	6	5
Range	None	None	5	3	2
Trails	None	5	3	1	1
Roads-Forest Service	None	8	4	3	2
-County/State	None	3	2	1	1
Power lines	None	10	8	6	3
Railroads	None	3	2	1	1
Gas lines	None	4	3	2	1

with herbicides, yet this is only 3,379 acres. Compare this with alternative E where a lower percentage of acres (2.0) is treated with herbicides, but number of acres treated is 11,328.

#### Environmental Effects

Numerous known and estimated environmental effects are discussed in chapter IV which forms the scientific and analytic basis for the comparisons in this section (40 CFR Part 1502.16). Chapter IV discloses effects on each environmental element. This section compares how all environmental elements are affected in each alternative. Chapter IV is technical and lengthy. This section summarizes information from chapter IV, and is less technical.

A comparison of the principal environmental effects of each alternative is presented in table II-8. Socioeconomic effects are shown in table II-9.

Human health effects are measured as risk to human health from use of herbicides, and risk of accidental injury from use of vegetation management tools. Indirect effects such as accidents related to wildfire occurrence and suppression are also stated.

Effects on wildlife and aquatic animals are measured as variety of habitats. While direct effects do occur, the indirect effect of altering habitat is the most important variable affecting wildlife and fisheries. Habitat is described by successional stage. Where areas are not treated at all, they tend to progress toward later successional stages.

Table II-8.—Comparison of environmental effects by alternative

		Human Health	Wildlife & Aquatics	Threatened, Endangered, Proposed, & Sensitive Species	Vegetation
Comparison Measure(s)		Risk to human health, risk of injury.	Variety of habitats.	Plant and animal species recovery.	Effect on woody under- and midstory species (ranking).
ALTERNATIVE TREATMENT	A (No Action)	No direct risks. Risks from wildfire are highest. Lowest overall risk.	Highly favors mid-late successional species. Early successional in natural disturbances and harvest areas only.	Habitat not managed, many species decline. Recovery not likely.	Woody under- and midstory highly favored. Intolerant hardwood and pine decline. Ranking = 1 (least effect)
	B	Very low risk to human health from herbicides, and very low risk of injury. Risk from wildfire high.	Favors mid-late successional species. Early successional habitat more available than A.	Known populations maintained, but recovery not likely.	Woody under- and midstory favored. Herbaceous understory favored only on corridors, fuel tmt, T&E areas. Ranking = 2.
	C	Herbicide risk is low; greater than B, less than F. Risk of injury moderate for manual and mechanical.	Favors mid-late successional species, but less than B. More early successional habitat than B, less than D.	Recovery of known populations likely.	Woody under- and midstory somewhat favored due to selective herbicides, low intensity fire and mechanical, increased manual. Ranking = 3.
	D	No herbicide risk. Risk of injury very high for mechanical, high for manual, moderate for prescribed fire.	Favors early successional stage species due to high use of mechanical and growing season burns.	Recovery of known populations likely.	Woody under- and midstory reduced, but less than F. Low-moderate intensity mechanical and fire favor herbaceous understory. Ranking = 7.
	E	Herbicide risk like B; more use but safer methods. Accident risk high for mechanical, moderate for others.	Mixed early-mid-late successional habitats, but early stage is limited due to increased manual.	Recovery of known populations likely.	Woody under- and midstory slightly favored. Less mechanical and more manual favor woody understory. Ranking = 4.
	F (Current)	Herbicide risk less than G or H, more than other alternatives. Accident risk high for mechanical, moderate for others.	Mixed early-mid-late successional habitats. Use of high intensity fire, mechanical, and herbicides favor early successional species.	Recovery of known populations likely.	Woody under- and midstory reduced. Broadcast herbicides, low-high intensity mechanical and fire favor herbaceous understory. Ranking = 8.
	G (Draft Preferred)	Overall herbicide risk slightly higher than F despite mitigation, but individual worker risk less than F. All accident risks moderate.	Mixed early-mid-late successional habitats. Broadcast herbicides, low-moderate intensity fire and mechanical slightly favor early-mid successional.	Recovery of known populations likely.	Woody under- and midstory reduced, but less than F. Broadcast herbicides, low-moderate intensity fire and mechanical favor herbaceous understory. Ranking = 6.
	MODIFIED G (Final Preferred)	Overall and individual herbicide risk slightly less than F due to mitigation. All accident risks moderate.	Mixed early-mid-late successional habitats. More selectivity yields more balanced mix than G.	Recovery of known populations likely.	Woody under- and midstory slightly reduced. More selectivity favors herbaceous less than G. Ranking = 5.
	H	Highest herbicide risk. Highest accident risk from all methods except manual.	Highly favors early successional species.	Recovery of known populations likely.	Woody under- and midstory reduced most. Intensive treatments highly favor herbaceous understory. Ranking = 9 (most effect).



Soil	Water	Air	Visual Quality	Cultural Resources
Risk of long-term soil productivity loss.	Tons of sediment, risk of herbicide pollution.	Acres burned. Tons of smoke produced annually.	Visibility of work. Meets VQO's.	Risk of loss or damage.
Moderate risk due to widespread, intense wildfires.	Wildfires produce significant sediment. No risk of herbicide pollution.	Slash burns = 0, underburns = 0, Wildfires = 92,000 ac. producing 62,500 tons of smoke.	No work done. VQO's not met for vistas, developed recreation sites, or other areas requiring manipulation.	Lowest - though wildfire may damage architectural resources.
Low to moderate risk due to some intense wildfires.	Wildfires produce some sediment. Treatments produce 20 tons. Negligible risk of herbicide pollution.	Slash burns = 0, underburns = 114,000 ac., wildfires = 52,000 ac. producing 36,800 tons of smoke.	Work generally not visible. VQO's may be met.	Low - wildfire may damage architectural resources.
Lowest risk due to restricted use of low disturbance tools.	Treatments produce 400 tons of sediment. Negligible risk of herbicide pollution.	Slash burns = 9,000 ac., underburns = 346,000 ac., wildfires = 15,000 ac. producing 41,100 tons of smoke.	Work less visible than present. VQO's may be met.	Low, but high where ripping or bedding are used.
Low risk, 19% more than C, due to use of low to moderate disturbance tools.	Treatments produce 840 tons of sediment. No risk of herbicide pollution.	Slash burns = 18,000 ac., underburns = 447,000 ac., wildfires = 12,000 ac. producing 45,200 tons of smoke.	Less browning visible than F, but overall visibility comparable. VQO's may be met.	Moderate, but high where ripping or bedding are used.
Low risk, 16% more than C, due to use of low to moderate disturbance tools.	Treatments produce 410 tons of sediment. Negligible risk of herbicide pollution.	Slash burns = 25,000 ac., underburns = 447,000 ac., wildfires = 12,000 ac. producing 46,900 tons of smoke.	Visibility comparable to present. VQO's may be met.	Moderate, but high where ripping or bedding are used.
Moderate risk, 3.0 times that of C, due to some use of high disturbance tools.	Treatments produce 1,270 tons of sediment. Negligible risk of herbicide pollution.	Slash burns = 13,000 ac., underburns = 451,000 ac., wildfires = 12,000 ac. producing 44,500 tons of smoke.	High visibility, significant disruptions. VQO's may be met.	High.
Low risk, 9% more than C, due to use of low to moderate disturbance tools.	Treatments produce 810 tons of sediment. Some risk of herbicide pollution.	Slash burns = 20,000 ac., underburns = 447,000 ac., wildfires = 12,000 ac. producing 45,100 tons of smoke.	Similar visibility to present, but of shorter duration. VQO's may be met.	Moderate, but high where ripping or bedding are used.
Low risk, 9% more than C, due to use of low to moderate disturbance tools.	Treatments produce 670 tons of sediment. Low risk of herbicide pollution.	Slash burns = 20,000 ac., underburns = 447,000 ac., wildfires = 12,000 ac. producing 45,100 tons of smoke.	Similar visibility to present, but of shorter duration. VQO's may be met.	Moderate, but high where ripping or bedding are used.
Highest risk, 7.4 times that of C, due to emphasis on high disturbance tools.	Treatments produce 2,980 tons of sediment. Most risk herbicide pollution.	Slashburns = 8,000 ac., underburns = 660,000 ac., wildfires = 9,000 ac. producing 51,200 tons of smoke.	Foreground and middle-ground strongly influenced by work. May not meet VQO's.	Highest.

Table II-9.--Effects of alternatives on socioeconomics

Alternative	Total Cost	Cost/Acre	Indirect Cost	Resource Outputs	User Expectations	Employment Opportunity
A No Action	N/A	N/A	Highest	Favors unmanaged	Favors primitive	Lowest
B	\$ 2,028,000	\$15.54	Much higher than current	Favors unmanaged	Favors primitive	Much lower than current
C	5,972,000	14.40	Higher than current	Favors unmanaged with some managed	Favors primitive to semi-primitive	Higher than B but lower than current
D	8,757,000	15.82	High for non-herbicide use	Comparable to current	Favors semi-primitive but allows all settings	Higher than current but lower than E
E	7,992,000	14.43	Comparable to C	Slightly lower than current	Comparable to C	Highest
F Current	8,802,000	15.90	Moderate	Favors both managed & unmanaged	Allows all, but favors semi-primitive/roaded natural	Moderate
G Draft Preferred	8,366,000	15.11	Lower than current	Comparable to current	Comparable to current but shift toward semi-primitive	Comparable to current
Mod. G Final Preferred	8,429,000	15.23	Lower than current	Comparable to current	Comparable to current but shift toward semi-primitive	Comparable to current
H	12,618,000	15.75	Lower than current	Favors managed	Favors roaded natural/rural	Higher than current

Evaluation of effects on threatened, endangered, proposed, and sensitive species of plants and animals considers whether or not it is possible to achieve recovery. Recovery is the primary objective of management activities for these species.

Effects on vegetation are generally reflected as changes in species composition. Species composition is the kinds, numbers, and distribution of plants growing on a site. Table II-8 shows effects on woody and herbaceous vegetation and ranks alternatives based on their effects on woody vegetation. Generally, treatments (or lack of treatment) favoring woody vegetation will negatively affect herbaceous vegetation, and conversely.

Alternatives are ranked according to their potential to cause long-term soil productivity losses. Risk of lost soil productivity is based on soil compaction and loss of organic matter, nitrogen, and soil organisms. Such effects may occur from use of prescribed fire, raking, piling, or biological methods. Effects vary depending on soil type. Alternatives are ranked by determining how much of each treatment is used, and on which soil types.

Two different effects on water are displayed in table II-8. Tons of sediment produced annually means the estimated sediment produced by vegetation management treatments which reaches streams despite mitigation measures. The other effect is the potential for herbicide pollution of streams.



Effects on air quality from vegetation management activities result mainly from smoke produced by prescribed fires and wildfires. In some alternatives, lack of vegetation management increases acres burned by wildfire. Table II-8 displays numbers of acres burned by all types of fire and lists total tons of smoke produced annually.



Visibility of work and achievement of visual quality objectives are two measures of effects on visual quality. Whether or not vegetation management work can be seen by the average user depends largely upon how many acres are treated and where the work is located. Another factor contributing to visibility is intensity of work. Vegetation management treatments often improve appearances of harvested sites. Visual quality objectives (VQO's) are goals for desired visual conditions which have been established for all landscapes.

Estimated risk of damage or loss is used to state effects on cultural resources. Damage or loss is most likely wherever the ground is disturbed. Some cultural resources may also be affected by fire. Effects from ground disturbance increase with depth of soil penetration. Risks related to fire increase with increased wildfire occurrence, but generally not with increased use of prescribed fire.

#### Economic and Social Effects

Economic and social effects are in table II-9. Six types of effects are shown.

Total cost reflects the annual expenditure necessary to accomplish the vegetation management program. It is calculated by determining the cost of using each method for each activity and multiplying by number of acres treated.

Cost per acre is actually an average cost determined by dividing total cost by total acres treated. Average costs are influenced by methods used for treatment, as some methods are more costly than others.

Indirect costs and opportunity costs are hard to quantify. It is also not always easy to determine who pays these costs. For example, if good silvicultural practices aren't used, sites won't produce wood products to their capability. This results in lower harvest volumes, thus lower receipts to the treasury. Lower receipts result in lower payments to counties, which in turn often result in higher taxes to maintain services. Another example is that no maintenance of rights-of-way causes damage to facilities within them. On a power line, the utility company spends more for repairs, and these extra costs are passed on to consumers and shareholders.

Resource Outputs are classed as managed or unmanaged. Most outputs such as wildlife, timber, recreation, and forage require some form of management, but some like wilderness or late successional species occur in the absence of vegetation manipulation.

User expectations cover a range from primitive to rural settings. These settings are explained in chapter III.

Generally, as more intensive treatments are done, more expectations toward the rural end of the scale are met.

Employment opportunity is stated qualitatively (low to high), and reflects only those jobs directly associated with vegetation management. Number of jobs available depends on the labor intensity of methods used and number of acres treated. Manual methods are the most labor intensive.

#### H. SUMMARY OF COMPARISON OF ALTERNATIVES

This section is a brief summary of the effects of the alternatives displayed in tables II-8 and II-9. For more detail, see section IV.N.

Alternative A has the lowest risk of many effects because no vegetation management is done. No herbicides are used, so there is no risk of adverse **health effects** or **water pollution** from them. An increase in acres and intensity of wildfires creates a substantial risk of **injury** to firefighters, users, and neighbors. Mid to late successional **wildlife** species such as gray squirrel increase over present levels, but early successional species such as quail decline. Many populations of **threatened, endangered, proposed, and sensitive** plant and animal species cannot recover, and fire-dependent species such as gopher tortoise decline. Woody **vegetation** thrives while herbaceous vegetation and shade-intolerant plants decline. There is moderate risk of reduced **soil productivity** from intense wildfires, and no treatment-caused **sediment** is produced. **Air quality** is impaired more in this alternative than any other, due to the high acreage burned by wildfire. **Visual quality** is not impaired by vegetation treatments, but areas like vistas which require treatment cannot be maintained. Risk to **cultural resources** is extremely low, but damage from wildfire occurs. No funds are expended for vegetation management, but indirect **costs** are highest. Facilities within rights-of-way deteriorate and some are abandoned. Growth and yield of pines, hardwoods, and forage decline in proportion to the amount of competition. Resource and property damage from wildfires is high. **Revenue** and returns to counties decline over time and are the lowest of all alternatives. All managed **outputs** decline. Forest Land and Resource Management Plan objectives cannot be achieved. Primitive and semi-primitive **settings** increase substantially over time, while other settings decline. There is no **employment** provided by vegetation management.

Alternative B has a very low risk of many effects because little vegetation management is done, only to protect resources such as threatened, endangered, proposed, and sensitive species or health and safety. Risk to **human health** from herbicides is very low but higher than A or D. Limited use of other methods also means a very low risk of accidental **injury**. Wildfires are more widespread than

currently, so risk to firefighters, users, and neighbors is higher. Effects on **wildlife** are comparable to alternative A, but where treatments are done, more early successional habitat for species such as eastern meadowlark is available. Known populations of **threatened, endangered, proposed, and sensitive** species are maintained but recovery of many species is not likely because no additional habitat is created. Effects on **vegetation** are similar to alternative A. Where treatments are done, more herbaceous species are favored. Only low-intensity methods are used so effects on **soil productivity** and **water quality** occur mostly from intense wildfires. **Smoke** production is lowest in this alternative. There is little noticeable difference in **visual quality** between this alternative and A. Work can be done on vistas and other areas needing treatment, so visual quality objectives are met. Risk to **cultural resources** is comparable to A. Risk from wildfires is reduced, but significantly higher than current. This alternative has the lowest total program **cost**, but per acre cost is higher than alternatives C, E, or D. Indirect costs are comparable to A (very high). Facilities in rights-of-way are costly to maintain, but are not abandoned unless abandonment is less costly than emergency maintenance. **Revenue** and returns to counties become very low over time, only slightly higher than alternative A. Unmanaged **outputs** are strongly favored, but managed output levels benefit from treatments done. Forest Land and Resource Management Plan objectives cannot be achieved. Primitive and semi-primitive **experiences** are favored, with few being semi-primitive motorized. **Employment** opportunities are far lower than current, and only somewhat higher than alternative A.

Alternative C treats about three times as many acres as alternative B, 80 percent as many acres as currently, to achieve minimum resource objectives.. Risk to **human health** from herbicides is low for workers, though higher than alternative B. Risk to the public is very low. Manual and mechanical methods are used more extensively than in alternative B, so **accident** frequencies are higher, though very comparable to current for manual. Mid to late successional **wildlife** species such as gray squirrel are favored. The number of acres treated creates more early successional habitat for species such as mourning dove than alternative B, but less than the other alternatives. **Threatened, endangered, proposed, and sensitive** species can recover. Low intensity tools favor woody **understory** species. Risk of lost **soil productivity** is lowest and sediment production is very low. Selectivity of herbicide application minimizes potential **water** pollution. **Smoke** production is lower than all other alternatives but B. Wildfire incidence is reduced to nearly current levels. Work is more visible than in alternative B because more acres are treated, but target specific controls cause fewer



impacts than present. **Visual quality** objectives may be met. Risk of loss or damage of **cultural resources** is lower than alternatives D through H. Total program **cost** is lower than present, though nearly three times the cost of alternative B. Per acre treatment cost is lowest, comparable to alternative E. Indirect costs are significantly lower than alternatives A or B, but remain high due to reduced effectiveness of some treatments. Both managed and unmanaged **outputs** are gained, but unmanaged outputs are favored. Forest Land and Resource Management Plan goals and objectives cannot be achieved, but are more nearly achieved than in A or B. Primitive and semi-primitive **experiences** are favored, as in alternative B, but more motorized experiences are possible. **Employment** is significantly increased compared to B, but remains below current levels.

Alternative D does not use herbicides, so risk to **human health** and **water quality** from herbicides does not exist. Because other methods are used in place of herbicides, risk of accidental **injury** is very high. Early successional **wildlife** such as mourning dove are favored by use of mechanical methods and growing season burns. **Threatened, endangered, proposed, and sensitive** species can recover. Effects on woody **understory** are greater than alternatives A, B, C, and E. Herbaceous understory is favored by mechanical and prescribed fire use. Risk of lost **soil productivity** is about 19 percent greater than alternative C, but 60 percent less than F. **Sediment** produced is higher than in all other alternatives except F and H. The amount of **smoke** produced is about the same as F. **Visibility** of work is about the same as current, but browning caused by herbicides is absent. Visual quality objectives may be met. Risk of loss or damage to **cultural resources** is greater than in A, B, or C because more mechanical methods are used. Total program **cost** is slightly lower than current. Indirect costs are incurred whenever herbicides would have been more cost-effective. **Outputs**, managed and unmanaged, vary little from current levels. **Experiences** can be had in all settings, with more semi-primitive settings than current. More **employment** opportunities than currently available are offered.

Alternative E stresses use of manual methods and prescribed fire. The number of acres treated with herbicides is less than half the current level. **Human health risk** is only slightly greater than alternative D to workers and very low to the public. **Accidental injuries** from manual methods are very high, while accidents from other methods are generally lower than current. All successional habitat stages are provided for **wildlife**, but wherever manual treatments are done, mid to late successional species such as gray squirrel are favored. **Threatened, endangered, proposed, and sensitive** species can recover. **Woody species** are slightly

favorable over herbaceous species, especially where less mechanical or more manual treatments are used. Risk of lost **soil productivity** is 16 percent higher than alternative C, and 61 percent lower than F. **Sediment** production is far lower than present and comparable to alternative C. Risk of **water** pollution from herbicides is very low. **Smoke** production is slightly higher than current. There is little difference in **visual quality** between this alternative and F. Visual quality objectives may be met. Risk to **cultural resources** is less than current due to fewer mechanical treatments. Total program **cost** is about 10 percent less than current. Cost per acre is comparable to the lowest cost realized in alternative C. Indirect costs are comparable to alternative C, due principally to reduced effectiveness (duration of effect) of some treatments. Though managed and unmanaged **outputs** are produced, managed output levels are slightly lower than current. Types of **experiences** are comparable to alternative C where primitive to semi-primitive settings dominate. **Employment** opportunities are highest, due to widespread use of labor-intensive methods.

Alternative F is the current level of treatment specified in Forest Land and Resource Management Plans. Risk of adverse **health** effects from herbicides is low for workers and the public. Risk of exposure is lower than in G or H. Risk of accidental **injury** is high where manual methods are used, and moderate for other methods. **Wildlife** habitat is mixed for early, mid and late successional species. Where high intensity treatments are done, early successional species such as mourning dove and meadowlark are favored. **Threatened, endangered, proposed, and sensitive** species can recover. Effects on woody **vegetation** are more severe than any other alternative except H. Herbaceous understory is favored. Risk of lost **soil productivity** and **sediment** production is higher than all other alternatives except H. **Smoke** production is slightly lower than alternative E. Vegetation treatments are often highly **visible** and exhibit significant disruptions. Visual quality objectives may be met. Risk of potential loss or damage of **cultural resources** and total program **cost** are higher than all other alternatives but H. Per acre cost is highest of all. Indirect costs are moderate compared to other alternatives. Managed and unmanaged **outputs** are both produced, with managed outputs favored. The full range of **experiences** is available, but most settings are semi-primitive or roaded natural. **Employment** levels are moderate compared to other alternatives.

Alternative G introduces aerial application of herbicides but reduces intensity of other methods from current. More people are **exposed** to herbicides, but additional mitigation increases individual **safety** above current levels. Risk

of accidental **injury** is slightly higher than F, but much lower for mechanical. A mixture of early, mid and late successional **wildlife** habitats is available. Early to mid successional stages are favored where broadcast herbicides, mechanical treatments, or growing season burns are used. **Threatened, endangered, proposed, and sensitive** species can recover. Effects on woody **vegetation** are reduced from current levels. Herbaceous vegetation is favored where broadcast herbicides, mechanical methods, or moderate intensity prescribed burns are used. Risk of **soil productivity** loss is less than D or E. **Sediment** production is slightly lower than alternative D and about 35 percent lower than current. **Smoke** production is about the same as F. Treatments are as visible as they are now, but effects don't last as long. **Visual quality** objectives may be met. Reduced use of mechanical methods reduces risk to **cultural resources** compared to F. Total program **cost** is about 5 percent lower than current, and per acre cost is lower than alternatives B, D, F, and H. Indirect costs are somewhat lower than current, principally due to availability of aerial herbicide application. **Output** mixes are about the same as current, though opportunity exists for unmanaged outputs to increase due to lower intensity treatments. **Experiences** cover the range of settings as in F, but more primitive settings are slightly more favored. **Employment** opportunities are similar to current, with a few more jobs in manual treatments.

Alternative Modified G somewhat reduces total use and broadcast (aerial and ground) application of herbicides from alternative G. As a result, human exposure is less and mitigations reduce **health** risk below current levels. Risk of accidental **injury** is slightly higher than F, due to increased use of manual methods and prescribed fire. The most balanced mix of early, mid and late successional **wildlife** habitats is provided by more selective herbicide use and moderate treatment intensities of other methods. **Threatened, endangered, proposed, and sensitive** species can recover. Effects on woody **vegetation** are less than in alternative G due to less broadcast herbicide use. Risk of **soil productivity** loss is the same as in G, but **sediment** production and risk of herbicide pollution of **water** are less due to a drop in aerial and other broadcast applications. **Smoke** production is the same as G. Effects on **visual quality** and **cultural resources** are also similar to alternative G. Total program and per acre **costs** are slightly more than G but still less than D and F. Indirect costs, **output** mixes, user **experiences**, and **employment** opportunities are the same as in alternative G.

Alternative H treats more acres than any other alternative (45 percent more than current) to achieve maximum competition control. Risk to **human health** from herbicides is low, but higher than any other alternative due to the



larger number of acres treated. Risk of accidental **injury** is very low from manual methods, but higher from other methods than any other alternative. Earlier successional stage **wildlife** such as mourning dove are highly favored. **Threatened, endangered, proposed, and sensitive** species can recover. This alternative has the greatest effect on woody **vegetation**. Herbaceous vegetation is highly favored by more intensive treatments. Risk of lost **soil productivity** is highest, 2.5 times the risk of alternative F. **Sediment** production is also double that in F. **Smoke** production is higher than for alternatives B through G, due to more prescribed burning, but wildfire acreage is less than current levels, keeping smoke production below alternative A. **Visual quality** is strongly influenced in the foreground and middleground, so work is highly visible. Visual quality objectives may not be met. Extensive use of mechanical treatments in this alternative creates the highest risk of damage or loss of **cultural resources**, though mitigation measures keep these effects from being serious. Total program **cost** is highest of all, and per acre cost is high but slightly lower than current. Indirect costs are lower than current for most **outputs**, except that unmanaged and non-market outputs decline as market outputs are stressed. Some Forest Land and Resource Management Plan objectives are not met, especially for non-market outputs. **Experiences** in roaded natural and rural settings are favored. **Employment** is higher than all alternatives except E.

#### Aerial Application

Three alternatives include **aerial application of herbicides** by helicopter. This technique reduces worker exposure but increases potential for offsite drift and accidental water contamination due to overflight of streams. **Alternative G** aerially treats 7,000 acres per year, or 14 percent of its herbicide program. Most of these are for rights-of-way maintenance and some are for site preparation. **Alternative Modified G** reduces aerial application to 2,500 acres per year, or 6 percent of its herbicide program. **Alternative H** expands use of aerial application to 28,000 acres per year, or 43 percent of its herbicide program. Most of these are for site preparation and rights-of-way, but some are for release work. Mitigation measures including use of low-drift delivery systems and buffer strips along streams reduce risk of water contamination and offsite drift.

Aerial application of herbicides is currently suspended by the Chief of the Forest Service. If the Record of Decision includes aerial application, the Regional Forester will request the suspension be lifted prior to using aerial methods.

#### I. IDENTIFICATION OF PREFERRED ALTERNATIVE

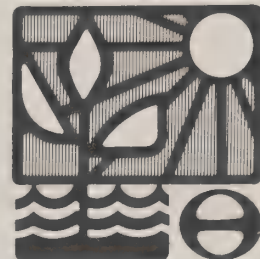
Alternative **Modified G** is the Forest Service's preferred alternative. The Draft EIS identified alternative G as preferred, but it was modified in response to public comment (chapter VI) and results of the environmental analysis (chapter IV).

# **Affected Environment**

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## CHAPTER III

### AFFECTED ENVIRONMENT

#### IN BRIEF

Part A describes the geographic area analyzed and gives a general description of physiography and climate. Part B gives more detailed descriptions of facets of the environment that may be affected by proposed activities.

#### A. PHYSICAL AND BIOLOGICAL SETTING

This environmental impact statement covers national forests and national grasslands in the Coastal Plain/Piedmont (table III-1). These lands total 4.6 million acres in eight states.

Table III-1.--Administrative units covered by the EIS

STATE	NATIONAL FOREST - NATIONAL GRASSLAND
Alabama	Conecuh, Tuskegee, Talladega (Oakmulgee Division)
Florida	Apalachicola, Choctawhatchee, Ocala, Osceola
Georgia	Oconee
Louisiana	Kisatchie
Mississippi	Bienville, Delta, DeSoto, Holly Springs, Homochitto, Tombigbee
North Carolina	Croatan, Uwharrie
South Carolina	Francis Marion, Sumter(except Andrew Pickens District)
Texas	Angelina, Davy Crockett, Sabine, Sam Houston; and Caddo and Lyndon B. Johnson National Grasslands

All or parts of 23 national forests and two national grasslands are covered. These units are managed by eight Forest Supervisors, one in each State.

#### 1. Physiography

The South contains five physiographic divisions (figure III-1). This EIS covers the Coastal Plain/Piedmont.

The Coastal Plain is part of the Continental Shelf that has been raised above sea level. It lies on young sediments deposited by ocean and river currents. Altitude is 0-600 feet. The varied landscapes compose three broad zones:

# PHYSIOGRAPHIC DIVISIONS OF THE SOUTHERN REGION



Figure III-1.--Physiographic subregions and States in the Forest Service's Southern Region.

(1) The Upper Coastal Plain is an interior belt of sandy hills bordering the Piedmont. Topography is rolling to hilly and is sharply dissected by stream channels. This zone is the upper hills landtype.

(2) The Middle Coastal Plain is a broad expanse of rolling, sandy and loamy uplands broken by narrow belts of clay lowlands and river valleys. Landtypes in this zone include the oak savannahs, clay flatlands, rolling uplands, loess uplands, and limestone plains.

(3) The Lower Coastal Plain includes the Mississippi Valley, flatwoods along the Atlantic and Gulf coasts, and Florida. Topography is flat and little dissected. High water tables and wetlands are common in the Mississippi Valley and flatwoods. Sand ridges and lakes are common in central Florida.

The Piedmont is a rolling to hilly upland on old, deeply weathered metamorphic and igneous rocks. Formerly a rugged highland, it was worn by erosion to a dissected plateau that slopes gently from the Appalachians to the Coastal Plain. Streams have carved narrow valleys among broad ridges and slopes. Abusive farming from 1800 to 1940 caused severe soil erosion. Altitude is 500 to 1500 feet.

## **2. Climate**

The Coastal Plain/Piedmont has a humid subtropical climate with hot, humid summers and mild winters. Gulf and Atlantic air masses dominate the weather. Thunderstorms are frequent in spring and summer. Hurricanes occasionally strike the coast, bringing torrential rains. Winter precipitation is caused by frontal systems.

Precipitation averages 45-60 inches per year and falls 90-120 days per year. Even the driest summer month receives at least 1.2 inches of rain. Spring and summer droughts do occur, however, and fall is commonly the driest season. Thunderstorm activity, total rainfall, and rainfall intensities are highest along the Gulf Coast.

Average annual temperature is 60-70° F. July temperatures range from highs of 90-95° F to lows of 65-75° F. January temperatures have ranges of 35-55° F in the Piedmont and 50-70° F in Florida. The growing season is 200-300 days, but frost occurs nearly every winter. Snow falls rarely and melts quickly. Relative humidity averages 70-75 percent.

## **B. ENVIRONMENTAL ELEMENTS**

### **1. Vegetation**

#### **a. Forest**

Over the years several classification systems have been developed to group regional vegetation associations. These systems have focused on climatic, geographic, historic, and potential (biological) vegetation occurrence. Of the many systems developed, three commonly used are Braun's (1950) description of forest regions, Kuchler's (1966) potential natural vegetation, and Bailey's (1980) ecoregions. This section uses Kuchler's (1966) potential natural vegetation units to give a general description of the Coastal Plain/Piedmont.

No one system necessarily describes in detail the overstory, midstory, and understory of forests, so examples of some common woody species appear in tables III-2 through III-4. Examples of herbaceous species are given in the range discussion. More detailed descriptions of specific forest cover types, vegetation associations, and plant communities can be found in Forest Land and Resource Management Plans, FSH 2409.26, and papers by Oosting (1956), Barbour, Burk, and Pitts (1980), Wahlenberg (1946), Snedaker and Lugo



(n.d.), and Wade, Ewel, and Hofstetter (1980). Three broad forest vegetation regions occur in the Coastal Plain/Piedmont:

(1) Oak-hickory-pine forests, covering approximately 77 million acres of Federal, State, and private land, are the most widespread. Many people recognize these as loblolly-shortleaf-hardwood forests. They are interspersed throughout all three Coastal Plain landscape zones, and comprise the majority of all forested areas in the Piedmont from North Carolina to east Texas. These forests are recognized as containing mixtures of both pine and hardwood species. Braun (1950) classified them to be within parts of the oak-hickory, southeastern evergreen, and oak-pine forest regions, and Bailey (1980) classified them as part of the Southeastern Mixed Forest Province.

Loblolly, shortleaf, and to a much lesser extent Virginia pine, predominate. Hardwoods are codominant with pine over much of the area, and significant hardwood mid- and understories are characteristic of these forests. Most common are species of oak and hickory, along with dogwood, persimmon, sweetgum, elm, redcedar, yellow poplar, black tupelo, and red maple. Common shrubs and vines include American beautyberry, hawthorns, hollies, blueberries, viburnums, greenbriers, blackberry, yellow jessamine, honeysuckle, and grape. A more comprehensive list of typical woody species of oak-hickory-pine forests is found in table III-2.

(2) Southern mixed and sand pine scrub forests, covering approximately 19 million acres of Federal, State, and private land, border the Atlantic and Gulf coasts from South Carolina to east Texas. These are more commonly known as longleaf-slash pine forests. They generally occupy the lower and middle Coastal Plain landscape zones. Braun (1950) classified these forests as part of the Southeastern evergreen forest region, and Bailey (1980) as part of the Outer Coastal Plain Forest Province.

Small amounts of loblolly and shortleaf pine do occur in these forests, but longleaf and slash pine predominate. Sand pine is unique to this grouping and occurs only in Florida and southeast Alabama.

Other tree species associated with longleaf-slash pine forests include turkey oak, bluejack oak, blackjack oak, myrtle oak, live oak, holly, titi, cabbage palmetto, and southern magnolia. Where fire has been excluded, a heavy understory of volatile evergreen hardwood species such as palmetto and gallberry commonly occurs. Common shrubs and vines include rosemary, youpon, saw palmetto, scrub palmetto, runner oak, sand post oak, wax myrtle, gallberry, staggerbush, St. Andrews cross, gopher apple, and greenbriers.

Table III-2.--Some representative woody species of oak-hickory-pine forests

Trees:

<u>Common Name</u>	<u>Scientific Name</u>	<u>Common Name</u>	<u>Scientific Name</u>
Red Maple	<u>Acer rubrum</u>	Red Bay	<u>Persea borbonia</u>
American hornbeam,	<u>Carpinus caroliniana</u>	Shortleaf pine	<u>Pinus echinata</u>
Ironwood		Loblolly pine	<u>Pinus taeda</u>
Bitternut hickory	<u>Carya cordiformis</u>	Virginia pine	<u>Pinus virginiana</u>
Pignut hickory	<u>Carya glabra</u>	Black cherry	<u>Prunus serotina</u>
Shagbark hickory	<u>Carya ovata</u>	White oak	<u>Quercus alba</u>
Mockernut hickory	<u>Carya tomentosa</u>	Scarlet oak	<u>Quercus coccinea</u>
Eastern redbud	<u>Cercis canadensis</u>	Southern red oak	<u>Quercus falcata</u>
Flowering dogwood	<u>Cornus florida</u>	Blackjack oak	<u>Quercus marilandica</u>
Common persimmon	<u>Diospyros virginiana</u>	Water oak	<u>Quercus nigra</u>
American beech	<u>Fagus grandifolia</u>	Willow oak	<u>Quercus phellos</u>
White ash	<u>Fraxinus americana</u>	Chestnut oak	<u>Quercus prinus</u>
Eastern redcedar	<u>Juniperus virginiana</u>	Northern red oak	<u>Quercus rubra</u>
Sweetgum	<u>Liquidambar styraciflua</u>	Shumard oak	<u>Quercus shumardii</u>
Yellow-poplar	<u>Liriodendron tulipifera</u>	Post oak	<u>Quercus stellata</u>
Red mulberry	<u>Morus rubra</u>	Black oak	<u>Quercus velutina</u>
Black tupelo, Blackgum	<u>Nyssa sylvatica</u>	Sassafras	<u>Sassafras albidum</u>
Eastern hophornbeam	<u>Ostrya virginiana</u>	Winged elm	<u>Ulmus alata</u>
Sourwood	<u>Oxydendrum arboreum</u>		

Shrubs and Vines:

<u>Common Name</u>	<u>Scientific Name</u>	<u>Common Name</u>	<u>Scientific Name</u>
Serviceberry	<u>Amelanchier arborea</u>	Blackberry	<u>Rubus</u> spp.
American beautyberry	<u>Callicarpa americana</u>	Saw greenbrier	<u>Smilax bona-nox</u>
Fringetree	<u>Chionanthus virginicus</u>	Cat greenbrier	<u>Smilax glauca</u>
Hawthorns	<u>Crataegus</u> spp.	Common greenbrier	<u>Smilax rotundifolia</u>
Yellow jessamine	<u>Gelsemium sempervirens</u>	Common sweetleaf	<u>Symplocus tinctoria</u>
Winterberry, possumhaw	<u>Ilex decidua</u>	Sparkleberry	<u>Vaccinium arboreum</u>
American holly	<u>Ilex opaca</u>	Deerberry	<u>Vaccinium stamineum</u>
Japanese honeysuckle	<u>Lonicera japonica</u>	Dryland blueberry	<u>Vaccinium vacillans</u>
Virginia creeper	<u>Parthenocissus quinquefolia</u>	Arrowwood	<u>Viburnum dentatum</u>
Shining sumac	<u>Rhus copallina</u>	Possumhaw viburnum	<u>Viburnum nudum</u>
Smooth sumac	<u>Rhus glabra</u>	Summer grape	<u>Vitis aestivalis</u>
Poison ivy	<u>Rhus radicans</u>	Muscadine grape	<u>Vitis rotundifolia</u>
Poison oak	<u>Rhus toxidodendron</u>	Rusty blackhaw	<u>Viburnum rufidulum</u>

Forests that receive periodic prescribed burns are primarily comprised of herbaceous understories dominated by grasses (see range vegetation discussion). The same hardwood tree, shrub, and vine species occur in prescribed burned areas as in unburned areas, but these species are generally limited to lower, wetter portions of fire-managed forests. A more comprehensive list of typical woody species of longleaf-slash pine forests is found in table III-3.

(3) Southern floodplain (bottomland) and pocosin forests, covering approximately 29 million acres of Federal, State, and private land, are interspersed throughout the entire Coastal Plain/Piedmont within loblolly-shortleaf and longleaf-slash pine forests. Bottomland forests have been categorized by Braun (1950) to be within the oak-pine and southern evergreen forest regions. In Bailey's (1980) ecoregions they are within both the Southeastern Mixed and Outer Coastal Plain Provinces.

These bottomland or floodplain forests occupy areas along streams, rivers, and lakes, and in bays, ponds, sloughs, hammocks, bayous, and swamps. Many of these areas are subject to periodic flooding. Common tree species include red maple, sugarberry, river birch, sweetgum, water hickory, black tupelo, American elm, sycamore, cottonwood, cherrybark oak, water oak, willow ash, and baldcypress. Shrubs and vines include buttonbush, swamp privet, fringetree, strawberry bush, possumhaw, trumpet creeper, Japanese honeysuckle, and greenbriar. A more comprehensive list of typical woody species of southern bottomland forests is found in table III-4.

b. Range

Range vegetation in the Coastal Plain/Piedmont is divided into five cover types: natural grassland, wet meadow, brush, conifer, and hardwood.

Grasslands are naturally occurring open areas where herbaceous species are dominant. They receive less precipitation than forests but more than deserts. Annual and perennial grasses, along with sedges and forbs, are the major herbaceous species in grasslands. Woody species are generally absent except for scattered shrubs or trees along rivers and streams. On the national grasslands in Texas, part of the original tall grass prairie, common dominant grasses include switchgrass (Panicum virgatum), Indian grass (Sorghastrum nutans), big bluestem (Andropogon gerardii), and little bluestem (Schizachyrium scoparium).



Table III-3.--Some representative woody species of southern mixed forests

Trees:

<u>Common Name</u>	<u>Scientific Name</u>	<u>Common Name</u>	<u>Scientific Name</u>
Florida maple	<u>Acer barbatum</u>	Shortleaf pine	<u>Pinus echinata</u>
Red maple	<u>Acer rubrum</u>	Slash pine	<u>Pinus elliottii</u>
American hornbeam,	<u>Carpinus caroliniana</u>	South Florida	<u>Pinus elliottii</u> var.
Ironwood		slash pine	<u>densa</u>
Pignut hickory	<u>Carya glabra</u>	Longleaf pine	<u>Pinus palustris</u>
Mockernut hickory	<u>Carya tomentosa</u>	Loblolly pine	<u>Pinus taeda</u>
Titi, Buckwheat-tree	<u>Cliftonia monophylla</u>	White oak	<u>Quercus alba</u>
Flowering dogwood	<u>Cornus florida</u>	Chapman oak	<u>Quercus chapmanii</u>
Titi, swamp cyrilla	<u>Cyrilla racemiflora</u>	Southern red oak	<u>Quercus falcata</u>
Common persimmon	<u>Diospyros virginiana</u>	Bluejack oak	<u>Quercus incana</u>
American beech	<u>Fagus grandifolia</u>	Turkey oak	<u>Quercus laevis</u>
American holly	<u>Ilex opaca</u>	Laurel oak	<u>Quercus laurifolia</u>
Sweetgum	<u>Liquidambar styraciflua</u>	Blackjack oak	<u>Quercus marilandica</u>
Yellow-poplar	<u>Liriodendron tulipifera</u>	Myrtle oak	<u>Quercus myrtifolia</u>
Southern magnolia	<u>Magnolia grandiflora</u>	Willow oak	<u>Quercus phellos</u>
Sweetbay	<u>Magnolia virginiana</u>	Live oak	<u>Quercus virginiana</u>
Eastern hophornbeam	<u>Ostrya virginiana</u>	Cabbage palmetto	<u>Sabal palmetto</u>
Red bay	<u>Persea borbonia</u>	Winged elm	<u>Ulmus alata</u>
Sand pine	<u>Pinus clausa</u>		

Shrubs and Vines:

<u>Common Name</u>	<u>Scientific Name</u>	<u>Common Name</u>	<u>Scientific Name</u>
American beautyberry	<u>Callicarpa americana</u>	Runner oak	<u>Quercus pumila</u>
Rosemary	<u>Ceratiola ericoides</u>	Sand post oak	<u>Quercus stellata</u> var.
Gopher apple	<u>Chrysobalanus</u>		<u>margaretta</u>
	<u>oblongifolia</u>	Sand live oak	<u>Quercus virginiana</u>
Hawthorn	<u>Crataegus</u> spp.		var. <u>maritima</u>
Carolina jessamine	<u>Gelsemium sempervirens</u>	Shining sumac	<u>Rhus copallina</u>
St. Andrews cross	<u>Hypericum hypericoides</u>	Scrub palmetto	<u>Sabal etonia</u>
Large gallberry	<u>Ilex coriacea</u>	Bush palmetto	<u>Sabal minor</u>
Smooth gallberry	<u>Ilex vomitoria</u>	Saw palmetto	<u>Serenoa repens</u>
Yaupon	<u>Ilex vomitoria</u>	Saw greenbrier	<u>Smilax bona-nox</u>
Staggerbush	<u>Lyonia ferruginea</u>	Cat greenbrier	<u>Smilax glauca</u>
Fetterbush	<u>Lyonia lucida</u>	Common greenbrier	<u>Smilax rotundifolia</u>
Waxmyrtle	<u>Myrica cerifera</u>	Common sweetleaf	<u>Symplocos tinctoria</u>
Devilwood	<u>Osmanthus americanus</u>	Tree sparkleberry	<u>Vaccinium arboreum</u>
Dwarf live oak	<u>Quercus minima</u>	Ground blueberry	<u>Vaccinium myrsinites</u>

Table III-4.--Some representative woody species of southern bottomland forests

Trees:

<u>Common Name</u>	<u>Scientific Name</u>	<u>Common Name</u>	<u>Scientific Name</u>
Red maple	<u>Acer rubrum</u>	Wax myrtle	<u>Myrica cerifera</u>
River birch	<u>Betula nigra</u>	Black tupelo	<u>Nyssa silvatica</u>
American hornbeam,	<u>Carpinus caroliniana</u>	Red bay	<u>Persea borbonia</u>
Ironwood		Slash pine	<u>Pinus elliottii</u>
Water hickory	<u>Carya aquatica</u>	Spruce pine	<u>Pinus glabra</u>
Bitternut hickory	<u>Carya cordiformis</u>	Loblolly pine	<u>Pinus taeda</u>
Pecan	<u>Carya illinoensis</u>	Pond pine	<u>Pinus serotina</u>
Sugarberry	<u>Celtis laevigata</u>	Water elm	<u>Planera aquatica</u>
Eastern redbud	<u>Cercis canadensis</u>	Eastern cottonwood	<u>Populus deltoides</u>
Titi, Buckwheat-tree	<u>Cliftonia monophylla</u>	Sycamore	<u>Platanus occidentalis</u>
Flowering dogwood	<u>Cornus florida</u>	Cherrybark oak	<u>Quercus falcata</u> var. <u>pagodaefolia</u>
Titi, Swamp cyrilla	<u>Cyrilla racemiflora</u>	Laurel oak	<u>Quercus laurifolia</u>
Common persimmon	<u>Diospyros virginiana</u>	Overcup oak	<u>Quercus lyrata</u>
American beech	<u>Fagus grandifolia</u>	Swamp chestnut oak	<u>Quercus michauxii</u>
Green ash	<u>Fraxinus pennsylvanica</u>	Water oak	<u>Quercus nigra</u>
Pumpkin ash	<u>Fraxinus profunda</u>	Nuttall oak	<u>Quercus nuttallii</u>
Waterlocust	<u>Gleditsia aquatica</u>	Willow oak	<u>Quercus phellos</u>
Black walnut	<u>Juglans nigra</u>	Shumard oak	<u>Quercus shumardii</u>
Sweetgum	<u>Liquidamber styraciflua</u>	Black willow	<u>Salix nigra</u>
Yellow-poplar	<u>Liriodendron tulipifera</u>	Baldcypress	<u>Taxodium distichum</u>
Southern magnolia	<u>Magnolia grandiflora</u>	American elm	<u>Ulmus americana</u>
Sweetbay	<u>Magnolia virginiana</u>		
Red mulberry	<u>Morus rubra</u>		

Shrubs and Vines:

<u>Common Name</u>	<u>Scientific Name</u>	<u>Common Name</u>	<u>Scientific Name</u>
Red buckeye	<u>Aesculus pavia</u>	Smooth gallberry	<u>Ilex glabra</u>
Peppervine	<u>Ampelopsis arborea</u>	Yaupon	<u>Ilex vomitoria</u>
Devils walking stick	<u>Aralia spinosa</u>	Virginia willow	<u>Itea virginica</u>
Rattan vine	<u>Berchemia scandens</u>	Japanese	<u>Lonicera japonica</u>
Trumpet creeper	<u>Campsis radicans</u>	honeysuckle	
Button bush	<u>Cephalanthus</u> <u>occidentalis</u>	Devilwood	<u>Osmanthus americanus</u>
Fringetree	<u>Chionanthus virginicus</u>	Poison ivy	<u>Rhus radicans</u>
Hawthorn	<u>Crataegus</u> spp.	Poison sumac	<u>Rhus vernix</u>
Strawberry bush	<u>Euonymus americanus</u>	American elder	<u>Sambucus canadensis</u>
Swamp privet	<u>Forestiera acuminata</u>	Laurel greenbrier	<u>Smilax laurifolia</u>
Carolina jessamine	<u>Gelsemium sempervirens</u>	Common greenbrier	<u>Smilax rotundifolia</u>
Large gallberry	<u>Ilex coriacea</u>	Tree sparkelberry	<u>Vaccinium arboreum</u>
Possumhaw	<u>Ilex decidua</u>	Possumhaw viburnum	<u>Viburnum nudum</u>

Wet meadows are areas dominated by herbaceous species that generally maintain continuous growth during most of the growing season and have seasonally wet periods that prohibit grazing. In these areas, sedges, rushes, grasses, and forbs along with occasional shrubs predominate.

In the brush cover type, shrubs and small tree species are dominant. Availability and persistence of herbaceous species depend on the amount of brush cover. In dense brush vegetation, herbaceous species may be severely limited. Post oak and blackjack oak represent the more "tree-like" brush vegetation which occurs on the LBJ National Grassland in Texas. Cedar, wild plum, and sumac represent the more "shrub-like" vegetation which occurs on the Caddo National Grassland in Texas.

Herbaceous range plants grow within conifer and hardwood forests. These categories occur as understory species within the previously described forests. The conifer range cover type refers to the oak-hickory-pine and southern mixed forests, while the hardwood range cover type refers to the southern bottomland hardwood forests. The more important woody browse species are discussed in the forest vegetation section and listed in tables III-2 through III-4.

Within oak-hickory-pine forests, common herbaceous range forage species in open areas include little bluestem (Schizachyrium scoparium), pinehill bluestem (S. scoparium var. divergens), broomsedge bluestem (Andropogon virginicus), crabgrass (Digitaria spp.), panicums (Panicum spp.), and paspalums (Paspalum spp.). Beneath denser canopies the spikegrasses (Uniola spp.) predominate. Common forbs, comprised mainly of legumes and composites, include tickclovers (Desmodium spp.), lespedeza (Lespedeza spp.), partridgepea (Cassia spp.), goldenrod (Solidago spp.), aster (Aster spp.), ragweed (Ambrosia spp.), dogfennel (Eupatorium capillifolium), yankee weed (E. compositifolium), and blackeyed susan (Rudbeckia hirta).

Within longleaf-slash pine forests, herbaceous range forage vegetation is divided into two associations (see figure III-2). In the western Gulf Coastal Plain, the dominant herbaceous vegetation is bluestem grasses. Most common among the grass species are little bluestem (Schizachyrium scoparium), pinehill bluestem (S. scoparium var. divergens), slender bluestem (A. tener), broomsedge bluestem (A. virginicus), pineywoods dropseed (Sporobolus junceus), panicums (Panicum spp.), and paspalums (Paspalum spp.).

In the eastern Gulf Coastal Plain, species of wiregrass are the dominant herbaceous vegetation associated with longleaf-slash pine forests. Pineland threeawn (Aristida



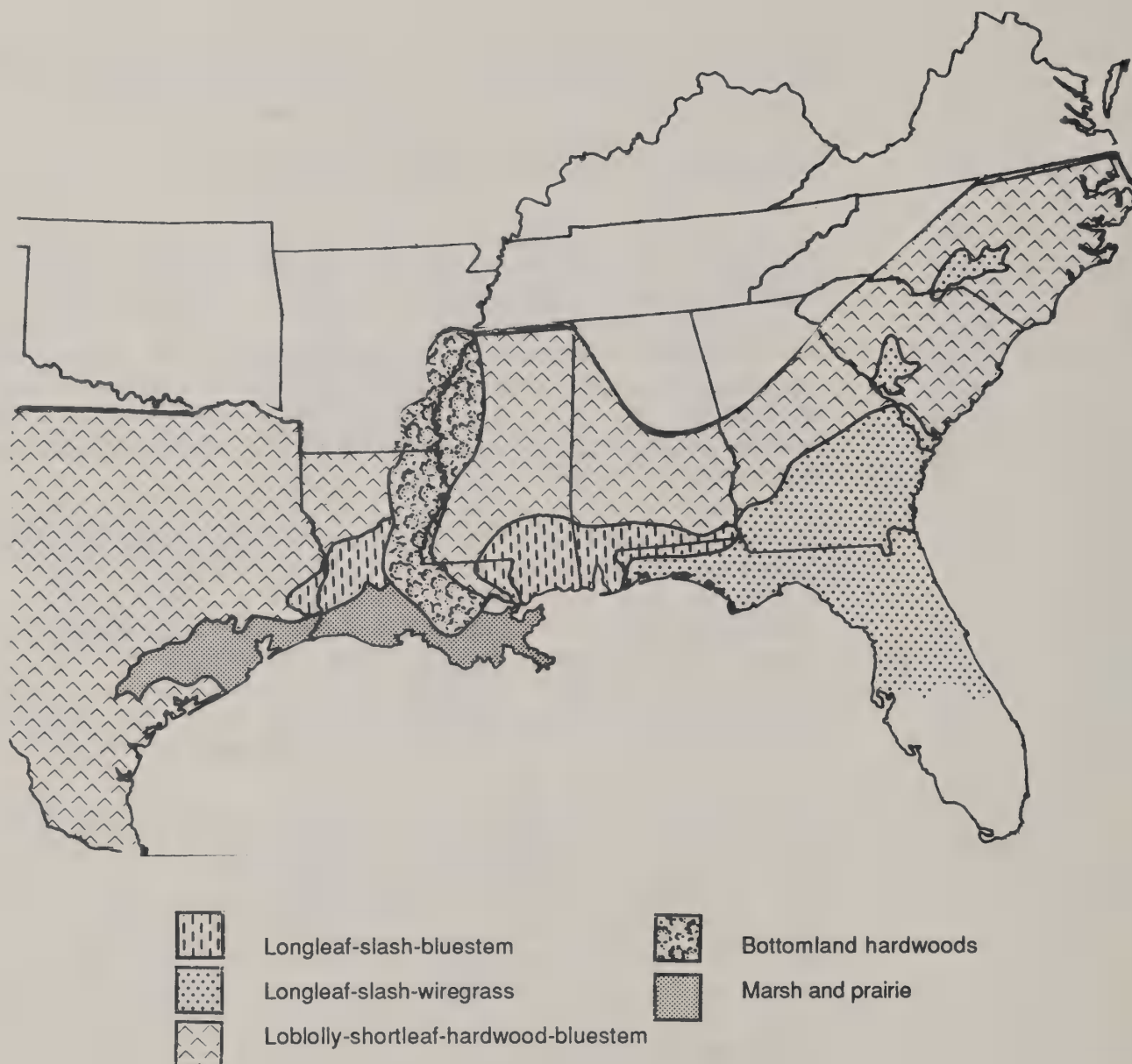


Figure III-2.--Forest range types of the Coastal Plain/Piedmont.

stricta), bottlebrush threeawn (A. spiciformis), and arrowfeather threeawn (A. purpurascens) are the most prevalent wiregrasses. Other common grasses include creeping bluestem (Schizachyrium stoloniferum), chalky bluestem (Andropogon capillipes), broomsedge bluestem (A. virginicus), curtis dropseed (Sporobolus curtissii), lopsided indiagrass (Sorghastrum secundum), panicums (Panicum spp.), and paspalums (Paspalum spp.).

Forbs common to both associations include tickclover (Desmodium spp.), lespedeza (Lespedeza spp.), partridge pea (Cassia spp.), tephrosia (Tephrosia spp.), rhynchosia (Rhynchosia spp.), asters (Aster spp.), eupatoriums (Eupatorium spp.), goldenrod (Solidago spp.), deer tongue

(Trilisia odoratissima), grassleaf goldaster (Herterotheca graminifolia), and swamp sunflower (Helianthus angustifolius). Other plant species, such as bracken fern (Pteridium aquilinum), cinnamon fern (Osmunda cinnamomea), and prickly pear cactus (Opuntia humifusa) are also prominent in these forests.

Use of range forage is highest in Texas, Louisiana, Mississippi, and Florida. Except for the national grasslands in Texas, most of the range resources are associated with regeneration areas and openings within longleaf-slash and loblolly-shortleaf pine forests.

In 1986 on national forests and grasslands in the Coastal Plain/Piedmont, 17,861 cattle and 23 horses used approximately 142,000 animal unit months of forage on 381 range allotments totalling 1.2 million acres.

#### c. Wilderness

There are 171,539 acres of wilderness in the Coastal Plain/Piedmont. Wilderness areas vary in size from 940 to 24,600 acres. The wilderness system ranges from bays, swamps, and hardwood river bottoms to rolling pine uplands, and includes a wide variety of plants and animals. Exclusion of fire has increased the risk of wildfire and has complicated fire control.

Vegetation management is not generally practiced in wilderness areas, but natural or prescribed fire may be necessary to ensure protection of threatened and endangered species and reduce unnatural fuel buildups. Other forms of vegetation management are minor.

#### d. Fire Management

Periodic natural and man-caused fires influenced the formation of Coastal Plain/Piedmont ecosystems (Komarek 1968; Kozlowski and Ahlgren 1974; Wade 1983). Coastal Plain pine forests are recognized as fire-dependent subclimax formations (Braun 1950; Oosting 1956). Many plants in these forests, such as wiregrass, pitcher plants, and longleaf, pond and sand pine, specifically depend upon fire during parts of their life cycles.

Fire exclusion from the late 1920's until the late 1940's adversely affected fire-dependent ecosystems where fire had previously maintained them. Today fire management is used to reduce damage from wildfire and maintain fire-dependent ecosystems, as well as for other purposes. Average annual acres treated by prescribed fire are:

1. Fuel Reduction	<u>180,000</u>
2. Wildlife Habitat (including T&E)	<u>81,000</u>
3. Range Management	<u>34,000</u>
4. Site Preparation	<u>15,000</u>
5. Timber Stand Improvement	<u>32,000</u>

## 2. Wildlife and Aquatic Animals



Southern forest and grassland ecosystems support a great variety of terrestrial and aquatic animal life. This variety reflects the wide range of climatic conditions, forest and range types, and successional stages on national forests and grasslands.

Big-game species include white-tailed deer (Odocoileus virginianus), eastern wild turkey (Meleagris gallopavo), and black bear (Ursus americanus). Important small-game species are bobwhite quail (Colinus virginianus), eastern mourning dove (Zenaida macroura), cottontail rabbit (Sylvilagus floridanus), gray (Sciurus carolinensis) and fox squirrel (Sciurus niger), ruffed grouse (Bonasa umbellus), several species of waterfowl, and American woodcock (Scolopax minor). Major fur-bearing species include raccoon (Procyon lotor), mink (Mustela vison), muskrat (Ondatra zibethicus), gray fox (Urocyon cinereoargenteus), red fox (Vulpes fulva), bobcat (Lynx rufus), and eastern coyote (Canis latrans). Game fish include cool-water species such as smallmouth bass (Micropterus dolomieu), warm-water species such as largemouth bass (Micropterus salmoides), and anadromous species such as striped bass (Morone saxatilis). Thousands of other species of birds, mammals, reptiles, amphibians, fish, and invertebrates also live in or near our forests and grasslands.

The Forest Service routinely manages habitat for game and nongame wildlife and fish. State wildlife resource agencies are responsible for establishing wildlife management regulations and enforcement. These efforts are integrated and coordinated through cooperative programs of the Forest Service and other agencies. They may include active habitat management by cooperators, especially State wildlife resource agencies.

## 3. Threatened, Endangered, Proposed, and Sensitive Species



Sixteen animal species classified by the Fish and Wildlife Service as threatened or endangered (or proposed for listing as threatened or endangered) live in Coastal Plain/Piedmont national forests or grasslands. These species include three mammals, seven birds, five reptiles, one fish, and one mollusk. Six threatened or endangered plant species also occur. Habitats of these species are managed under authority of the Endangered Species Act with the goal of population recovery. Appendix E lists these species and describes their habitats.

In addition, certain species for which population viability is a concern are designated by the Regional Forester as sensitive. This designation is normally established with concurrence and guidance of appropriate State Heritage Agencies. Habitats of sensitive species are managed to ensure population levels which will keep these plants and animals from becoming threatened or endangered. Appendix E lists these species currently designated as sensitive, and describes their habitats.



#### 4. Soils

Soils of the Coastal Plain/Piedmont vary with geology, climate, topography, and land-use history. Six soil orders occur in substantial amounts.

(1) Ultisols are highly developed acid soils with strong clay buildup in subsoil and intense leaching of bases. These loamy to clayey soils are usually rather deep with few rock fragments. They dominate the Piedmont and Middle Coastal Plain. Seasonally saturated ultisols dominate the Atlantic flatwoods and are associated with organic soils in swamps and pocosins.

(2) Alfisols are well developed neutral soils with some clay buildup in subsoil and slight leaching of bases. These loamy to clayey soils are usually rather deep with few rock fragments. They dominate the loess uplands along the Mississippi Valley and the oak savannahs in Texas.

(3) Vertisols are mixed clays that crack when dry. These soils dominate the clay lowlands of Mississippi.

(4) Entisols are undeveloped soils low in organic matter or clay accumulation. They occur largely as acid, permeable sands in the Upper and Lower Coastal Plain. Entisols in river valleys, however, result from flood deposition and are often deep with thick topsoil and very weak or no subsoil.

(5) Inceptisols are poorly developed, acid, loamy soils that occur mostly in the Lower Coastal Plain. They are often shallow with thin topsoil and little clay buildup in subsoil. Inceptisols in river valleys, however, result from flood deposition and are usually deep with thick topsoil and weak subsoil.

(6) Spodosols are intensely leached sands with mixtures of organic matter, iron, and aluminum in subsoil. These soils occur largely in the Florida flatwoods.

Productivity of these soils depends much on their geology and land-use history. Topsoil contains most nutrients and organic matter. Most entisols, inceptisols, and spodosols have thin topsoil and are rather infertile. Seasonally saturated soils in the flatwoods are often deficient in phosphorus. Ultisols, alfisols, and vertisols are naturally fertile, but many soils in the Piedmont, loess uplands, and Upper Coastal Plain were severely depleted by massive farmland erosion from 1820 to 1940. Entisols and inceptisols in floodplains, enriched by deposition, are the most fertile soils.

Erosion hazard increases with slope steepness and is usually higher in weakly cemented or mica-rich loamy soils. During the wet season loamy and clayey soils in flatwoods and river valleys are especially subject to compaction from mechanical equipment. When wet, vertisols are also subject to equipment damage because they tend to shrink and swell.

## 5. Water



The humid subtropical climate of the Coastal Plain/piedmont produces abundant water. Annual runoff is 10-20 inches per year in most areas but exceeds 30 inches along the Gulf Coast. Streamflows are usually highest in winter and early spring and lowest in late summer and fall.

The Coastal Plain is underlain by aquifers of sand, sandstone, and limestone that produce ample ground water. Valley deposits of rivers flowing to the Gulf are productive aquifers. The metamorphic and igneous rocks of the Piedmont yield little water, so most use comes from surface sources.

In the Lower Coastal Plain, sandy soils, flat slopes, and level streams limit erosion and sediment yield. Streams are wide and shallow and strongly influenced by water tables. Floodplains are broad, and watershed divides are hard to distinguish.

In the Middle and Upper Coastal Plain, stream and floodplain dimensions vary with geology and size of stream. Channel erosion is often the most important source of sediment, but potential surface erosion is especially high in the loess uplands along the Mississippi Valley.

In the Piedmont, streams and floodplains tend to be narrow. Intense rains can produce significant sediment from gullies. Potential surface erosion is high, but much sediment is caused by channels naturally cutting through valley deposits from past farmland erosion.

National forests and grasslands contain over 3,600 miles of perennial streams and 110,000 acres of lakes and ponds. Nearly 70 percent of the lake area occurs in the Florida sand ridges. Surface water generally exceeds water quality standards except where degraded by upstream land uses.

Wetlands are abundant in the Lower Coastal Plain but are confined mostly to floodplains elsewhere. More than 90 percent of the 600,000 acres of wetland occurs in the Lower Coastal Plain. Executive Orders 11988 (Floodplain Management) and 11990 (Protection of Wetlands) protect the flood-moderating value of floodplains and the ability of wetlands to produce abundant and diverse biota, regulate water flow and quality, and recharge ground water.

## 6. Air

In the dormant season, air flow and quality are dominated by migrating, frequently changing air masses and storm systems. In the growing season, air flow and quality are dominated by the Atlantic high-pressure system whose clockwise movement pumps in tropical air from the Gulf of Mexico. Prevailing winds in all seasons are from the southwest.

Air quality is generally good in winter and spring when rapidly changing weather patterns tend to keep the atmosphere well mixed. Occasional stagnation periods in summer and fall cause natural and manmade pollutants to concentrate. No major industrial centers occur in the area, but pollutants emanate from local sources including cities. Pollutants may also be transported into the region from long distances.

Air quality in Class I areas is considered best and is mandated for special protection. Air quality in Class II and III areas exceeds National Ambient Air Quality Standards established by EPA, but protection is not as stringent as in Class I areas. All of the Coastal Plain/Piedmont is Class I or II. Five Class I areas are potentially affected (table III-5).

Table III-5.--Class I areas and jurisdictions

<u>Class I Area</u>	<u>State</u>	<u>Responsible Agency</u>
Bradwell Bay Wilderness	FL	USDA Forest Service
St. Marks National Wildlife Refuge	FL	USDI Fish and Wildlife Service
Okefenokee National Wildlife Refuge	GA	USDI Fish and Wildlife Service
Cape Romain National Wildlife Refuge	SC	USDI Fish and Wildlife Service
Swanquarter National Wildlife Refuge	NC	USDI Fish and Wildlife Service

Only Bradwell Bay Wilderness is on national forest land. The other four Class I areas, however, are within 60 miles of national forests and could be affected by management actions. Other potentially affected areas are highways, airports, and populated areas downwind from national forests.

## 7. Rights-of-Way Corridors

Rights-of-way include roads, trails, utility corridors, and railroads. Historically, vegetation control programs for rights-of-way maintenance have included the full range of options including manual, mechanical, biological, fire, and herbicides.



a. Roads



Roadside vegetation is controlled to protect investments and user safety. Forest Service roads in the Coastal Plain/Piedmont total 12,800 miles. Using mostly mechanical methods, crews maintain about 13,000 acres of vegetation along roads to one of five levels. Amount of traffic and maintenance requirements increase with each level:

<u>Maintenance Level</u>	<u>Miles</u>
1	1,247
2	6,986
3	3,558
4	928
5	81
Total	12,800

Roads and highways maintained by other Federal, State, and county agencies total 2,077 miles, requiring 23,000 acres of maintenance. Vegetation management is performed on road shoulders to enhance drainage; on cut and fill slopes to provide increased sight distance; and along roadsides to control danger trees.

b. Trails

Trails provide outdoor recreation opportunities and access to scenic and cultural resources. Trailside vegetation is controlled to protect user safety and investments and enhance trailside appearance. Manual and mechanical methods are chiefly used.

The 1,452 miles of trail that require vegetation management are used for: hiking (733 miles), horseback (294 miles), off-road vehicles (158 miles), and canoes (267 miles).

c. Utility Corridors

Many power and communication utilities have above-ground and buried cable lines through national forests. Vegetation management is done in these areas to enhance transmission system reliability, protect public and worker safety, and access facilities. Some rights-of-way are maintained annually and others intermittently at up to 10-year intervals.

There are 3,325 miles of such corridors of varying width that occupy 9,698 acres of national forest land. About 1,600 acres are maintained each year. Vegetation control programs are used to keep trees from growing across conductors, thus preventing power outages and possible forest fires. Vegetation is also controlled along access roads. Mechanical, herbicide, and manual methods are used.

Vegetation controls are used annually on about 2,250 acres along 1,000 miles of oil and gas pipelines. These controls allow for detection of leaks, control of undesirable plants, public and worker safety, and access.

#### d. Railroads

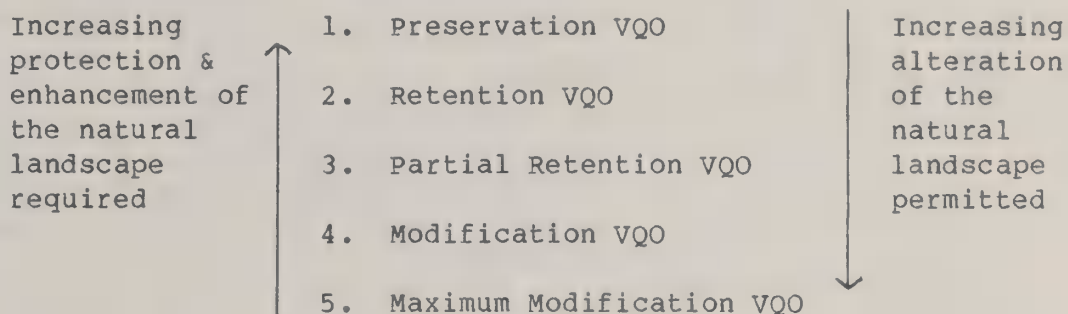
Railroad transportation systems have rights-of-way, access roads, crossings, and communication facilities that receive annual vegetation control on national forest lands. All methods may be used. Only 5 miles of railroad right-of-way exist on national forests.

#### 8. Visual Quality

Landscapes vary from thick swamps to open grasslands. Prominent features of these landscapes include rock forms and landforms, water forms, and vegetative patterns.

Inventoried visual quality levels are determined by "distance zone," the distance at which a landscape is viewed; "sensitivity level," the number and interest level of people viewing the scene; and "variety class," the interest and visual diversity a landscape affords.

A Visual Quality Objective (VQO) is assigned to each landscape which describes the degree of alteration permissible for each management situation. This VQO does not always match the inventoried condition. VQO's constitute a ranking which can be described as follows:



#### 9. Cultural Resources

Cultural resources are artifacts, buildings, or sites resulting from past human activity. They can be archaeological, historical, prehistoric, or architectural. Cultural resources are irreplaceable and of great concern to the public. Examples are remnants of old wagon roads, homesteads, Civilian Conservation Corps structures, or native American camp sites or mound complexes.

Laws and regulations require that Federal agencies manage the cultural resources under their control. Procedures are followed to assure that cultural values are considered in any decision-making process. These procedures include inventorying, evaluating, determining effects, and mitigating adverse effects.

In the Coastal Plain/Piedmont, 15 percent of the area has been inventoried at varied intensities for cultural resources. About 2,000 historic and 4,000 prehistoric sites have been recorded through FY 1986.

## 10. Fuels

The climate and physiography of the Coastal Plain/Piedmont support nine major fuel types with differing burning characteristics. Fire intensity in any fuel type varies greatly with topography, weather (rainfall, humidity, wind), and the amount, size distribution, degree of concentration, moisture content, and chemistry of available fuels. In general, more fuels become available during periods of low live fuel moisture, as in fall and winter when vegetation is dormant or in spring and summer droughts. The major fuel types are:

- a. Hardwood found mostly in bottomlands and wetlands. Available fuels can include leaves, forbs, decaying woody material, humus, and evergreen hardwoods such as American holly. Fuel loads are generally low and support low intensity surface fires.
- b. Pine-hardwood distributed throughout the region. Overstory is pine or mixed pine-hardwood with hardwood understory. Available fuels can include needle and leaf litter, grass, forbs, decaying woody material, and evergreen hardwoods. Fuel loads are generally high in natural stands and support medium-intensity surface fires.
- c. Pine-grass located mostly in middle and lower Coastal Plain. Overstory is open pines that have been managed with periodic prescribed fires. Available fuels can include grass, forbs, needle litter, and scattered hardwood brush. Surface fires move rapidly and are generally of moderate intensity.
- d. Pine-palmetto/gallberry in lower Coastal Plain forests. Pines dominate the overstory. Available fuels can include grass, forbs, needle litter, dense palmetto or gallberry, and other brush. Fuel loads and flammability can be high, often supporting intense surface fires burning into crowns.
- e. Grass or plantations (before crown closure) distributed throughout the region, including national grasslands in Texas. Available fuels can include grass, forbs, and hardwood brush. Surface fires move rapidly and often involve pine foliage.
- f. Pine plantations (after crown closure) established throughout the region. Available fuels can include needle litter and scattered hardwood brush. Fuel loads are moderate and normally support slow to moderate moving surface fires with low to moderate intensity, depending on type and amount of brush present.
- g. Sand pine (a fire-dependent species) forming dense stands in Florida sand ridges. Available fuels are light needle litter and scattered forb-brush understory that produce low-intensity creeping fires. Sand pine needles contain combustible substances that can become flammable in dry weather and promote intense crown fires.



h. Pond pine (a fire-dependent species) found in North Carolina pocosins with dense evergreen and deciduous shrub understory. Available fuels are dense brush, live and dead needles, and humus. During droughts organic soils become available, causing intense fires that are hard to put out.

i. Logging slash associated with harvest cuts and heavy thinnings. Available fuels can include all cut down living and dead plant materials. Fires can be very intense if slash is heavy, concentrated, and dry.

## 11. Socioeconomics

Within the boundaries of national forests and grasslands in the Coastal Plain/Piedmont are 4 million acres of private land. Private landowners are mostly large industrial timber companies, residents, small businesses, and absentee landowners who use their land for recreation, farming, hunting, and woodlots.

### a. Population



The South's population has outpaced the nation's population growth rate since 1970, and this trend is expected to continue through 1990. Net migration from the Northeast and Midwest contributed substantially to the 1975-84 growth trends. The South was the only region to experience a net immigration from all other regions of the country (Dahmann 1986). The trend toward non-metropolitan areas which emerged in the 1970's appears to be reversing with non-metropolitan areas losing population in 1983-84 study. Movement from the central city to the suburbs continues. Growth is projected to continue into the future. The coastal States are expected to grow fastest, with Florida leading (table III-6).

Table III-6.--Population and population projections

State	Population (thousands)		Population Projections (thousands)	
	1977	1986	1990	2000
Alabama	3,691	4,052	4,214	4,415
Florida	8,466	11,676	13,316	17,438
Georgia	5,041	6,104	6,175	6,708
Louisiana	3,930	4,501	4,747	5,160
Mississippi	2,386	2,625	2,761	2,939
North Carolina	5,515	6,333	6,473	6,868
South Carolina	2,878	3,377	3,560	3,907
Texas	12,806	16,685	17,498	20,739
Total	44,713	55,352	58,744	68,174

## **b. Employment and Income**

Total employment in the Region has followed population trends, with 48 percent of the population being employed in 1986 (slightly below the U.S. ratio of 50 percent). Employment by major sector follows national trends, but the region shows slightly greater dependence on government employment. The small amount of durable-goods manufacturing has allowed the South to be less influenced by recessions than the rest of the nation. The region since the 1940's has escaped severe inventory corrections that cause unemployment (Haulk 1980). As a result, unemployment rates generally have been below national averages during periods of recession. Figure III-3 displays employment by major industry in the South, and table III-7 shows employment by major industries by State, 1983.

Agriculture and related services have declined in relative importance and account for less than 10 percent of total employment in the region. The decline has been more than offset by growth in the services sector. Rural counties make up a small part of the total population but are still very dependent on agriculture and related services for employment.

Per capita income for the South historically has been below the national average. In 1983, it averaged \$8,381, which is 12 percent below the national average. Wages and salaries earned in agriculture and light industry, predominant in the South, are lower than those earned in heavy manufacturing. Projections of per capita income reflect substantial increases at national and regional levels, with proportional gains in the South.

## **c. User Expectations**

The South has traditionally depended on forest and range resources for goods and services. Current projections indicate that these resources will become more important in the future. Land managers recognize that effects of their actions extend far beyond national forests and grasslands, and that they must be familiar with relationships between natural resource management and the social and cultural environment.

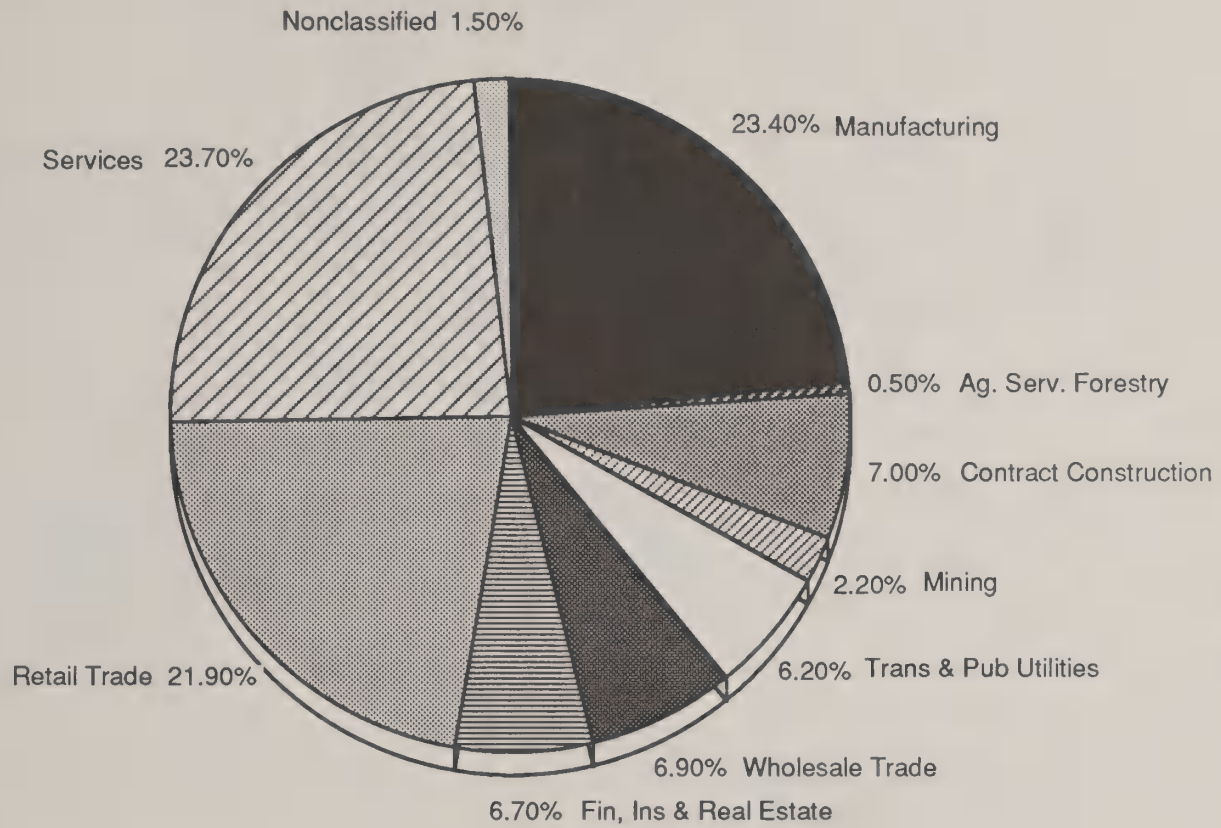
Forest users have diverse motives and expectations. Some value the very existence of forests and need not visit them to derive satisfaction. At the other end of the spectrum are people who value forests for products which contribute greatly to our high living standards.

People's expectations of the forest are fulfilled through experiences. These experiences can be recreational, occupational, or just casually related to the daily living environment. Forest experiences occur in one of five kinds of settings which combine physical, biological, social, and managerial conditions (table III-8 lists acreage for each setting):

(1) Primitive experiences occur in areas with extremely high probability of isolation from human activity, difficult access by foot, a closeness to nature, and a high degree of challenge and risk in a large area of unmodified natural environment. Management controls are primarily off-site.

## EMPLOYMENT BY MAJOR INDUSTRIES

### Southern Region



## EMPLOYMENT BY MAJOR INDUSTRIES

### Coastal Plain/Piedmont

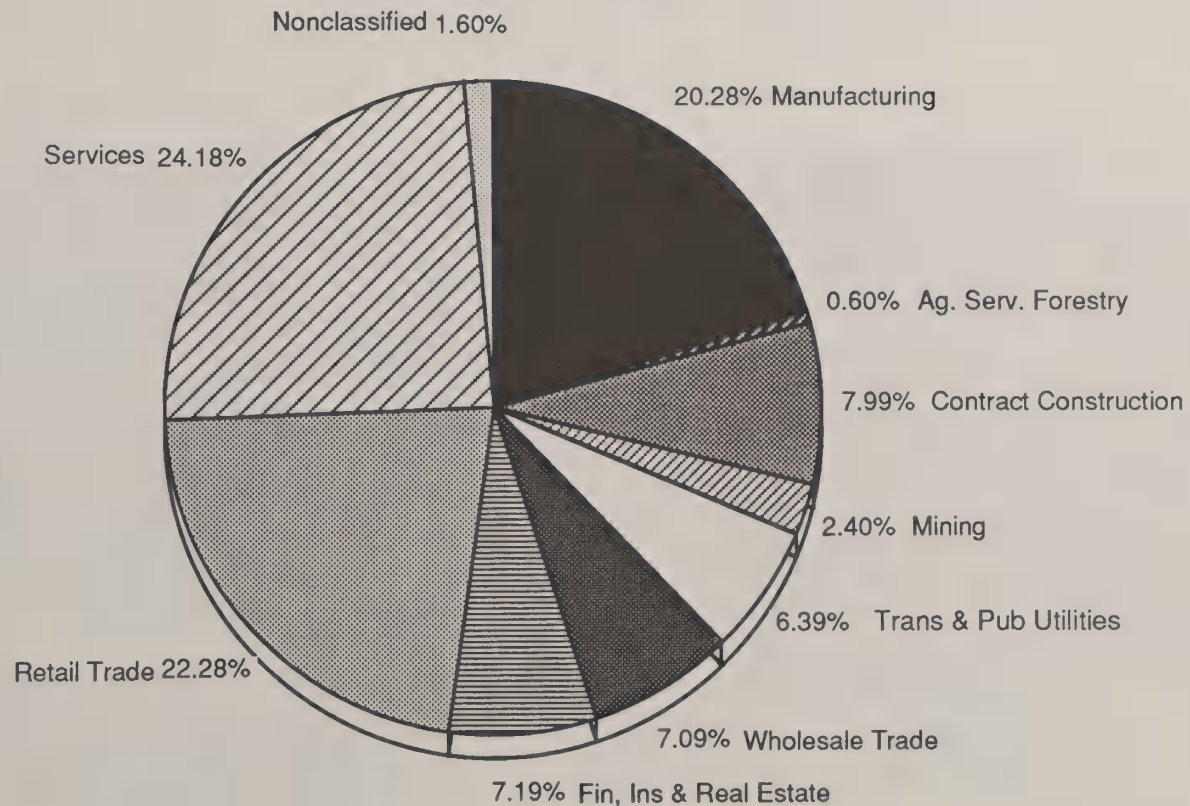


Figure III-3.--Employment by major industries



Table III-7.—Employment by major industries by State, 1983 (adapted from Bureau of Census data)

	<u>AL</u>	<u>FL</u>	<u>GA</u>	<u>LA</u>	<u>MS</u>	<u>NC</u>	<u>SC</u>	<u>TX</u>	<u>TOTAL</u>
Ag Serv For ■ Fisheries	4,798	32,676	10,776	5,422	3,534	9,731	5,432	29,172	101,541
Mining	14,034	12,489	7,826	81,489	8,599	3,468	1,749	264,579	376,233
Contract Construction	76,355	315,649	135,850	98,535	35,888	133,277	103,309	469,457	1,368,320
Manufacturing	340,772	499,207	560,624	177,735	211,841	840,496	364,518	1,002,470	3,997,663
Transport & Other Pub Util	68,637	225,425	150,174	108,124	34,576	127,677	43,181	360,538	1,118,332
Wholesale Trade	75,177	242,531	168,346	90,708	41,046	133,975	52,575	436,860	1,231,218
Retail Trade	228,238	933,269	442,438	291,237	134,037	421,175	207,818	1,231,475	3,889,687
Finance Ins & Real Estate	65,106	315,403	134,214	85,087	36,489	110,414	56,683	430,524	1,233,920
Services	237,663	1,103,132	447,783	316,592	119,570	412,369	197,338	1,332,521	4,166,968
Non- classified	15,583	54,982	28,315	17,675	10,294	27,296	14,856	85,508	254,509
TOTAL	1,126,363	3,734,763	2,086,346	1,272,604	635,874	2,219,878	1,047,459	5,625,104	17,748,391



Table III-8.--Experience settings\* (Approximate acres)

<u>Forest</u>	<u>SPNM</u>	<u>SPM</u>	<u>RN</u>	<u>R</u>
Alabama	5,000	8,000	230,000	500
Croatan/Uwharrie	83,000		116,000	
Florida	83,000	14,000	990,000	1,000
Francis Marion/Sumter	21,000	6,000	53,000	215,000
Kisatchie	33,000		528,000	3,000
Mississippi		44,000	950,000	146,000
Oconee			104,000	
Texas	41,000	104,000	524,000	4,000

\*No acres in the Coastal Plain/Piedmont are classed primitive

Key: SPNM - Semi-primitive non-motorized  
 SPM - Semi-primitive motorized  
 RN - Road natural  
 R - Rural

(2) Semi-primitive, non-motorized experiences occur in areas with high probability of isolation, access by foot, and a moderate to high degree of challenge and risk in a large area of natural or natural-appearing environment. Management controls may be present, but subtle.

(3) Semi-primitive, motorized experiences occur in areas with moderate degrees of isolation but some opportunity for vehicle use, risk, challenge and self-reliance in a predominately natural-appearing area of moderate size with limited access by road. Management controls are present with some dominant modifications.






(4) Roaded natural experiences occur in areas which have about equal probability of isolation and social contact. Challenge and risk are not often present. Some easily noticed dominant modifications occur, but management controls harmonize with the natural environment, with convenient access by road.

(5) Rural experiences occur in areas which have high probability for social interaction. Convenience is more important than challenge. Modifications are fairly constantly observed, controls are obvious and numerous, and access is designed for ease and comfort.

Vegetation management can enhance or impair these settings, and thus affect experiences. Table III-9 groups forest users into workers, neighbors and visitors. The table shows

some possible experiences for each group in each setting. Many experiences can be obtained in any setting and individuals can be members of different user groups at different times. Workers include employees, contractors, permittees, and cooperators. Neighbors include adjacent landowners, permittees, and local community residents. Visitors are those who come to national forests or grasslands for specific purposes, stay a short while (hours or days), then return home.

Table III-9.--Experiences by user groups in different settings

<u>SETTING</u>	<u>USERS</u>		
	<u>Workers</u> (Types of Work)	<u>Neighbors</u> (Types of Benefits)	<u>Visitors</u> (Types of Activities)
Primitive 	Trail maintenance	Viewing, solitude, vicarious benefits	Hiking, nature study, fishing, canoeing, tent camping, solitude, walking
Semi-Primitive Non-Motorized 	Resource inventory, inspections, limited resource work	Viewing, solitude, vicarious benefits	Hiking, nature study, fishing, hunting, camping, horseback riding, canoeing, swimming, solitude, walking
Semi-Primitive Motorized 	Cultural treatments, resource manipulation, enforcement	Vehicular access, viewing, contact with others, vicarious benefits	Nature study, fishing, hunting, camping, pleasure driving, off-road vehicle use, boating, riding, gathering products
Roaded Natural 	Cultural treatments, resource control enforcement, maintenance of services, wide range of intensity of work	Vehicular access, viewing, frequent contact with others. gathering products, vicarious benefits	Fishing, hunting, camping with services, pleasure driving, off-road vehicle use, boating, riding, gathering products games and play, interpretive services, cycling, picnicking
Rural 	Resource control, resource marketing, transportation, economy, high intensity work	Rural comfort in proximity to urban services, viewing, recreation cabin use, contact with others dominates	Road tours, camping with full service and facilities, viewing man's works, boating, cycling, organized games, gathering products, picnicking



# **Environmental Consequences**

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## CHAPTER IV

### ENVIRONMENTAL CONSEQUENCES

#### IN BRIEF

Part A describes the purposes of this chapter and defines the types of environmental effects analyzed. Parts B through M present the analysis of effects on each environmental element, and part N summarizes these effects for each alternative. Parts O through Q identify research needs, energy requirements, and conflicts with others. Parts R through T disclose unavoidable adverse effects, irreversible and irretrievable resource commitments, and relationships between short-term uses and long-term productivity.

#### A. INTRODUCTION

This chapter discloses the effects of each alternative on each environmental element described in chapter III, and forms the scientific basis for mitigation measures and comparisons of alternatives in chapter II.

If done without clear guidelines and reasonable restrictions some vegetation management activities can damage our environment. Many potential problems, however, can be anticipated, so ways to prevent them or minimize their severity can be required in advance. Management requirements and mitigation measures (chapter II, part E) are the "do's" and don't's" that workers and managers must use to protect our environment as they perform vegetation management.

To clearly display them to the reader, effects of vegetation management are discussed separately for each environmental element. Effects can be direct, indirect, or cumulative.

Direct effects occur at the same time and place as the actions that cause them. Their causes are usually obvious.

Indirect effects occur at a later time or different place than the actions that cause them. Their causes may not be obvious and may stem from effects on other environmental elements.

Cumulative effects are the combined effects of these actions with those of other past, present, and future actions. Cumulative effects can be on-site (confined to the project area) or off-site (outside the project area). Effects on vegetation, cultural resources, or soil are chiefly on-site. Effects on water and air quality or wildlife and fish are commonly off-site.



More precise definitions of these three effects are in 40 CFR 1508.

## **1. Scope of Analysis**

The Southern Region includes a variety of landscapes, plant communities, soil types, and climatic conditions. In order to account for some of these gross differences, we divide the Region into three parts for analysis of vegetation management activities. This environmental impact statement addresses only the Coastal Plain/Piedmont. See chapter III for a description of the Coastal Plain/Piedmont.

The area analyzed contains 4.6 million acres of national forests and has a complex variety of environmental conditions. We evaluate area-wide effects, and, where possible, sub-area effects. This approach is called "programmatic."

Within this broad area, site-specific vegetation management activities occur at hundreds of locations. Environmental effects from these projects vary with conditions on each project site. Many of these effects are predictable and are disclosed in this document. Other effects are unique to the site.

Recognizing this uniqueness, each project must be analyzed when proposed. The National Environmental Policy Act and Council on Environmental Quality Regulations describe a process called "tiering" to accomplish this evaluation. Tiering means the Forest Service will sometimes use this environmental statement and Forest Land and Resource Management Plans as references when we conduct further analysis. Chapter II (part E.1.a) explains requirements for site-specific project analyses.

Chapter II also describes environmental effects expected when different methods of vegetation management are used. Eight different ways (alternatives) to conduct the vegetation management program are evaluated. These approaches to doing work differ by:

1. Treating more or fewer acres either as a total or by individual methods.
2. Using or not using certain methods or tools.
3. Varying the intensity or frequency of application.

After reading about these effects and how they differ by alternative, the reader can refer back to chapter II, parts F, G, and H for comparison.

## **B. HUMAN HEALTH AND SAFETY**

Discussion of human health and safety is presented in three parts:

1. Effects of herbicides. Herbicide effects on human health are evaluated in a risk assessment (appendix A) and are summarized in this section.
2. Effects of burning herbicidally-treated fuels. This section deals primarily with the analysis of risk to workers from herbicide residues present on fuels at the time of burning. Also included is an evaluation of risk from burning treated firewood.
3. Effects of other methods of vegetation management. This section deals with workers' risk of accident when using manual, mechanical, or biological methods or during prescribed burning.

Each section contains information about how the analyses were performed, including a summary of exposure routes and amount of exposure, associated inherent risk of each tool, and an assessment of the resultant risk of exposing people to that tool.

The evaluation of risk has two major facets -- risk assessment and risk management. In addition to following the formal risk assessment process, this EIS presents management requirements and mitigation measures to manage (reduce) risk (chapter II).

### **1. Effects of Herbicides**

Source of  
Information



The human health risk assessment (appendix A) contains an analysis of the potential adverse effects to human health of 11 herbicides and 3 additives. The risk assessment was prepared by Labat-Anderson Inc. (LAI). Data from USDA Forest Service Agriculture Handbook #633 (Sassman and others 1984) and supplement (Sassman & Jacobs 1986) were updated based on more recent information provided to the Environmental Protection Agency (EPA) during the ongoing pesticide re-registration process. In addition, background documents were prepared for light fuel oil (Weeks and others 1988a) and for imazapyr (Weeks and others 1988b). No data invalidated by EPA are used.

In addition to consultation with EPA, both LAI and the Vegetation Management Team exhaustively searched the scientific literature concerning health effects of herbicides. Inquiries were made of 21 library and toxicology data bases (DB) including: Medline, Toxline, Embase, Hazardous Substances DB, Registry of Toxic Effects of Chemical Substances DB, BIOSIS Previews, CAB (Commonwealth Agriculture Board) Abstracts DB, and Enviroline DB.

When available, only EPA validated data are used. Where unavailable (either required data not yet validated or data which is not required for registration) data from the open scientific literature were used. In two cases (inert ingredient data, and data concerning the dermal penetration rate of triclopyr), corporate proprietary data (inert ingredient data is confidential business data) or a pre-publication summary were used.

Four sections of the risk assessment (appendix A) apply to the analysis of human health effects:

- Section 2 describes methods currently used to apply herbicides in the Southern Region.
- Section 3 documents basic toxic properties of the chemicals (the hazard analysis).
- Section 4 documents probable exposures of workers and the public to these chemicals (the exposure analysis) by combining information from section 2 with estimates of hours worked and chemical use-rates.
- Section 5 combines predicted hazards and exposures to estimate the danger to workers and public (the risk assessment).

Hazard  
Identification

Human health effects are evaluated based on dose/time relationships. These relationships are expressed as:

**Acute toxicity** -- the potential of a chemical to cause adverse health effects when administered in a single dose.

**Subchronic toxicity** -- the potential of a small dose of herbicide or additive administered daily for a relatively short period of time (generally about 30 days) to cause adverse health effects.

**Chronic toxicity** -- the potential of a small dose of herbicide or additive administered daily over a long period of time to cause adverse health effects.

Herbicides available to consumers are formulated products which contain technical product (active ingredient) and other chemicals or water (inert ingredients). Testing to determine toxic properties is done in the laboratory. Most tests are done with active ingredients, not formulated products (the product as sold, including active and inert ingredients).



Some evaluated health effects related to toxicity are:

**Mortality** -- death of test animals, which suggests the possibility of human death. Herbicide or additive toxicity is determined by the amount of chemical that kills one-half of the animals tested. EPA categories of acute toxicity are very slightly toxic (large amounts of chemical are needed to kill an animal); slightly toxic; moderately toxic; and severely toxic (small amounts of chemical are needed to kill an animal) (appendix A, table 3-1).

**Organ effects** -- abnormal growth (size or shape) or observable malfunction of organs. Generally the liver, kidney, and other major organs are closely monitored.

Doses which cause organ effects are stated as amount of herbicide or additive per unit of body weight per unit of time (generally milligrams of chemical per kilogram of body weight per day).

Exposure  
and Dose  
Response

To understand the subsequent discussion, a distinction must be made -- exposure and dose are NOT the same thing. Exposure is the amount of substance which an organism contacts in the environment. Dose is the amount of that substance which is taken into an organism (by breathing, eating, penetrating the skin, or any other route). Thus, dose can equal exposure, but normally it is much smaller.

In section 4 of the risk assessment, exposure levels of workers and the public are computed. Section 5 discusses the probable doses resulting from projected exposure levels. These levels cover the herbicides and additives proposed for use. Exposure estimates consider ways in which exposure occurs, such as specific public or worker activity, rate of herbicide application, size of treatment area, method of application, and physical characteristics of the chemical (persistence or drift potential). Dose is computed considering probable routes of chemical entry into the body (dermal penetration, blood transport from lungs, etc.) at the projected exposure level.

Each exposure/dose projection is a series of possibilities running from no exposure/dose to some theoretical maximum for each factor. The number of combinations for seasonal timing, method of application, chemical, length of field day, number of field days per year per worker, etc. is incredibly large. To reduce the number of possible combinations, three specific exposure/dose scenarios are analyzed. Specific data are applied to each chemical and application method. These data approximate current and projected field activities (appendix A). The scenarios for which risk assessment is performed are:

The **typical** situation estimates average dose resulting from exposure of workers and other people during routine operations.

The **maximum** situation estimates the highest probable doses resulting from exposure of workers and other people when highest rates of chemical are applied by crew members who work a maximum number of hours per day for a maximum number of days per year. Maximum application rates used in Forest Service projects range from 1/20 (picloram) to 1/2 (imazapyr) labeled rates.

An **accident** situation estimates dose resulting from exposure of workers and other people from direct exposure to herbicide resulting from a spill onto a worker or into a source of drinking water.

It is critical to remember that within each scenario ALL of the factors are relevant. The factors were mathematically modeled. Changing any factor changes the scenario and margin of safety projected for it. Risk is a function of dose -- but dose is critically dependent on several interrelated exposure factors and on toxicological properties of the chemical.

Potential movement of the herbicides and additives in the environment is estimated since this movement may also cause public exposure. Surface and subsurface movement (runoff and leaching) are estimated. Potential exposure due to drift of spray droplets is projected. Possible exposure as a result of either wildfire or deliberate burning (prescribed fire or firewood) is also predicted.

#### Exposure Information

Application rates and worker exposure times are based on actual projects and estimates of future use patterns in the Southern Region. Tables in the risk assessment show typical and maximum estimated hours per day and days per year a worker might be exposed, and typical and maximum amounts of chemical used per acre (tables 4-1 through 4-6).

Estimates of public exposure are made for skin contact and consumption of food or water from forests treated with herbicides. Skin exposure is computed for visitors on-site and for off-site neighbors. People's dietary exposure is computed for consumption of contaminated water, fish, meat from wildlife or cattle, vegetables, and berries.

Separate exposure calculations are made for different herbicide application methods because each method has its own potential to expose workers to herbicides. For example, a mechanical sprayer delivering herbicide 15 feet from the operator has far less likelihood of getting herbicide on the

worker than does a sprayer held in the worker's hand. Also, much less skin of a properly clothed worker (as in the typical operation) is exposed than with a worker not properly dressed (as for maximum exposure). The only route of exposure considered significant for workers in the typical operation is through the skin; however, in the maximum situation inhalation is also significant.

Accident projections are made using worst-case assumptions:

- large amounts of skin are bare or directly exposed;
- a person is sprayed with the full per-acre rate of application on all exposed skin;
- a full backpack tank of spray solution covers the worker's skin and soaks the clothing which is worn for the entire workday;
- a full helicopter tank of herbicide (100 gallons diluted for application) is spilled into a reservoir;
- a 5-gallon container of undiluted herbicide is spilled into a small pond; and,
- additional exposure occurs in both water scenarios by drinking 1 liter of contaminated water.

Risk  
Description

Section 5 of the risk assessment converts exposure/dose data to project adverse health effects. The relationship between exposure and dose is influenced by the rate at which the chemical penetrates the skin (or is inhaled or ingested); how soon it is washed off; its potential to be broken down in the body; and how efficiently body systems eliminate it. Risk is directly related to dose and chemical toxicity.

EPA (1974 and 1986b), the American Conference of Governmental Industrial Hygienists (1984), the National Agricultural Chemicals Association (1985), the National Research Council (1983 and 1986), and others have published standards for acceptable levels of chemicals in the environment, in ground water, or on foods. This EIS makes no value judgments (acceptable/unacceptable, safe/unsafe). It compares predicted risk with published standards to see if the herbicide or additive is more risky or less risky than the standard. Additional protective measures which reduce predicted risk to a level less than the standard are noted as management requirements or mitigation measures in chapter II.

Three measures of risk are:

**Margin of safety (MOS)** -- compares the NOEL (no observed effect level) for laboratory animals and the dose estimated for different application operations. The NOEL is the dose of a chemical which can be administered to test animals causing no visible effects in subchronic testing. NOELs are evaluated for systemic (on the test animals) and reproductive (on their offspring) effects.



According to the National Research Council (1986) acceptable levels of risk for a herbicide can be estimated. A safety factor of 10 based on test animal data, is used to predict human effects (between species variation). An additional factor of 10 is used to account for possible variations among humans (within species variation). If the NOEL divided by the dose results in a number greater than 100, a chemical is considered to pose an acceptable risk for the general population (excluding sensitive individuals). The higher this margin of safety, the lower the risk of adverse health effects. For example, if the NOEL is 100 mg/kg/day, then all doses of less than or equal to 1 mg/kg/day have margins of safety of 100 or greater (poses less risk than the standard), while all doses greater than 1 mg/kg/day have less than a 100 fold MOS (poses a greater risk than permitted under the standard).

**Mutagenic potential** -- the possibility that the herbicide or additive will cause a change in the basic information-carrying structure (DNA) in the cell's nucleus. This is of special concern in reproduction where altered genetic information might be inherited by offspring.

Evaluation of mutagenic potential is difficult. For some herbicides, no EPA-validated mutagenicity tests exist, or tests are insufficient to allow scientific conclusions. When no validated tests are available mutagenicity is assumed, and cancer potency values are used to indicate the degree of mutagenicity. This represents the worst-case assumption.

**Cancer potency** -- an estimate of the possibility that a single exposure or a lifetime exposure to a herbicide or additive might cause cancer.

#### Data Gaps



Gaps exist in our knowledge. Incompleteness of data results from registration laws, age of data (tests performed in the past may be judged inadequate by current registration standards), and results from two or more tests which disagree. The Council on Environmental Quality regulations discuss the process for evaluating incomplete and unavailable information (40 CFR 1502.22(a) & (b)).

Data gaps which result in uncertainty about reasonably foreseeable significant adverse human health effects include the following:

1. Human toxicity data; moral restrictions and laws generally prohibit tests on human subjects. Animal tests are evaluated and mathematical models are used to project probable effects on humans, but human toxicity data are lacking.

2. Data on field worker exposure are available only for 2,4-D, 2,4-DP, dicamba, picloram, and triclopyr. Neither dermal penetration rates nor exposure estimates using current technology and mitigation are available for the other herbicides or additives evaluated.
3. Oncogenicity (the ability to cause either cancerous or non-cancerous tumors) data is unavailable for limonene, is incomplete for imazapyr, and has caused scientific disagreement for 2,4-D, 2,4-DP, fosamine, glyphosate, light fuel oil, picloram and triclopyr (table 3-6, appendix A). Mutagenicity data are generally incomplete or inconclusive (table 3-5 and 3-6, appendix A).
4. The effects of smoke inhalation in forest fire settings is fairly well documented. However, knowledge of risk from burning fuels that have been treated with herbicides is incomplete.
5. Experimental information is not available on the public's exposure to herbicides applied using current methods.
6. Field studies on residue levels in plants or animals in and around treatment areas are lacking for several herbicides. Comparison of data is very difficult because existing studies use different analytical methods.
7. Data concerning the biochemistry and activity of breakdown products of herbicides formed by metabolic or environmental action is incomplete.
8. Information about synergistic effects of herbicide combinations with other herbicides and with inert ingredients is unavailable.
9. Data relating to cumulative effects are unavailable.

There have been recent changes about how to evaluate incomplete or unavailable data. The Council on Environmental Quality issued regulations in November 1978 (40 CFR 1502.22) which required that a worst case analysis be performed to estimate risk of relevant missing information. In 1986, they modified this requirement to allow analysis of "... reasonably foreseeable significant adverse effects to the human environment ..." (40 CFR 1502.22).

Recognizing that there are significant incomplete or unavailable data, we have prepared a risk assessment (appendix A) using the 1986 requirements. In the risk assessment, we evaluate maximum and accident scenarios (the worst case analyses required under earlier regulations). Thus, we have attempted to address both sets of regulations.

40 CFR 1502.22(b) requires that when costs for filling data gaps are exorbitant or, when means to obtain the data are unknown, the agency's evaluation of impacts must be based on theoretical approaches or research methods generally accepted in the scientific community. This analysis uses a risk assessment for missing data (appendix A). This approach which "is firmly based in scientific considerations... is a process of weighing alternatives and selecting the most appropriate actions" (National Research Council, 1983).

Although some of the data gaps are identified, an adequate data base was found to permit risk assessment of each of the 14 herbicides and additives within NEPA guidelines. Throughout the analyses, conservative estimates (greatest risk to humans) were used to approximate missing or incomplete data. The risk assessment provides worst case analyses (maximum and accident scenarios) of reasonably foreseeable scenarios in which extreme exposure to herbicide occurs.

Each test needed to provide data which are currently unavailable or incomplete costs from tens of thousands (mutagenicity, worker exposure) to over a million dollars (chronic toxicity, oncogenicity). If all tests were performed, direct costs would be tens of millions of dollars. In addition, by delaying vegetation management indefinitely to complete testing, the public would suffer increased hazard from wildfire, and production of goods and services would be reduced (see analysis of the effects of Alternative A). The Forest Service considers that delay-caused fire hazard, delay-caused deterioration of services, and costs to fill these data gaps are too great to justify postponing issuance of this environmental impact statement.

Despite the magnitude of this potential investment, the inherent difficulty of analysis of human health effects remains. Studies on animals are modeled to approximate human health effects, but, especially for chronic effects, the relevance of 2 to 4-year studies on animals when compared with a 60 or more year life span for a human has been seriously questioned. However, the relevance of the concept of chronic exposure when applied to relatively non-persistent herbicides is questionable.

#### Acute Toxicity

Acute toxicity is the potential to cause death when the dose is by mouth (acute oral toxicity) or by skin (acute dermal toxicity) or other route. Estimates of acute human toxicity are based on acute toxicity values (single-dose mortality) determined for test animals in laboratory experiments using pure (technical grade) herbicides, generally administered one herbicide at a time.



The more toxic the product, the less is required to cause death. A dose of more than a pint (16 fluid ounce) of a very slightly toxic herbicide is required to cause the death of an average adult (150 pound) human. Similarly, between 1 fluid ounce and a pint of slightly toxic herbicide would kill an adult; between a teaspoonful (1/6 fluid ounce) and one fluid ounce of a moderately toxic herbicide is lethal; but, less than a teaspoonful of severely toxic herbicide or additive is required to cause death.

Acute oral toxicities of the chemicals are (appendix A, table 3-2):

- Very slightly toxic--Diesel oil, fosamine, imazapyr, kerosene, limonene, picloram and sulfometuron methyl.
- Slightly toxic--Dicamba, glyphosate, hexazinone, tebuthiuron, triclopyr, and 2,4-DP.
- Moderately toxic--2,4-D.
- Severely toxic--None.

Acute dermal toxicities are reported to be (appendix A, table 3-3):

- Very slightly toxic--Dicamba.
- Slightly toxic--2,4-D, 2,4-DP, diesel oil, glyphosate, hexazinone, imazapyr, kerosene (tentative), limonene (tentative), picloram, sulfometuron methyl, and triclopyr.
- Moderately toxic--Fosamine and tebuthiuron.
- Severely toxic--None.

## Irritation

It is also necessary to know if a herbicide is an irritant: does it cause skin or eye problems? The risk assessment shows the amount of each chemical causing primary dermal or primary eye irritation. EPA (1974) categories are:

- IV- No irritation to the eyes; mild or slight skin irritation at 72 hours.
- III- No corneal opacity; moderate skin irritation at 72 hours.
- II- Corneal opacity reversible within 7 days; severe skin irritation at 72 hours.
- I- Irreversible corneal opacity at 7 days; corrosive to the skin.

Primary dermal irritations by the chemicals are (appendix A, table 3-3):

- Category IV--2,4-DP (Weedone formulation), dicamba, fosamine, glyphosate, imazapyr, kerosene, limonene, picloram, tebuthiuron and triclopyr.
- Category III--2,4-D, hexazinone and sulfometuron methyl.
- Category II--Diesel oil.
- Category I--None.

Primary eye irritations by the chemicals are (appendix A, table 3-3):

- Category IV--2,4-DP, diesel oil, kerosene and tebuthiuron.
- Category III--Dicamba, glyphosate, imazapyr, picloram and sulfometuron methyl.
- Category II--Hexazinone and triclopyr.
- Category I--2,4-D.
- No data--Fosamine and limonene.

No Observed  
Effect Levels

Systemic NOELs range from a low of 1 mg/kg for 2,4-D to a high of 500 mg/kg for imazapyr, but only 2,4-D, sulfometuron methyl, and triclopyr are less than 5 mg/kg (appendix A, table 3-2). Reproductive NOELs are reported between 2.5 mg/kg (dicamba and triclopyr) and 751 mg/kg (light fuel oils) (appendix A, table 3-2).

Effects of Inert  
Ingredients

An inert ingredient is not necessarily chemically unreactive; it is simply not the active ingredient in the formulation. EPA's Office of Pesticide Programs (EPA 1987) has identified about 1,200 inert ingredients currently used in pesticides, and they have categorized these chemicals based on their ability to cause chronic human health effects as follows:

- List 1--Inerts of toxicological concern: approximately 50 chemicals shown to be carcinogens, developmental toxicants, neurotoxins, or potential ecological hazards which merit highest priority for regulatory action.

- List 2--Potentially toxic inert: about 50 chemicals with toxicity data suggesting, but not confirming, possible chronic health effects or having chemical structures similar to chemicals on list 1. They are high priority for testing.
- List 3--Inerts of unknown toxicity: approximately 800 chemicals were placed here "... if there was no basis for listing it on any of the other three lists." Priority for further testing is low.
- List 4--Inerts of minimal concern: about 300 chemicals generally regarded as innocuous. Priority for testing is low.

Inert ingredient information is presented in the risk assessment (appendix A, table 3-8). None of the chemicals evaluated is on List 1 and only one chemical (kerosene) is on List 2. One additive is unclassified and the remaining inert substances are on list 3 or 4. In all cases, formulated products (the products as purchased which include both active and inert ingredients) have lower risk of acute toxic effects than the active ingredient alone (appendix A).

Current Forest Service policy is to permit use of formulations containing List 3 or List 4 inerts. Formulations containing List 2 chemicals are used only when no formulation with only List 3 or List 4 inert ingredients are available meet project objectives, and only after an evaluation of the inert ingredient shows that health risks are acceptable. Formulations containing List 1 inerts are not used.

#### Exposure Levels

Tables 4-25 through 4-40 in the risk assessment display projected public, worker and accident exposure levels. Important reference points are discussed below.

Berry pickers exposed to 0.14 mg/kg/day fosamine in the maximum exposure scenario represent the highest projected level of public exposure. Levels less than 0.00001 mg/kg/day are projected for public dermal exposure to drift of 2,4-DP and picloram, and for public dietary exposure to imazapyr (via fish), limonene (fish), picloram (fish), and sulfometuron methyl (water, fish, or meat) when these chemicals are applied at typical rates. Many worker exposure levels in the maximum scenario are greater than 1 mg/kg/day (a very high level of exposure). Maximum scenario exposures range from 1.5 to 100 or more times as great as typical exposure levels. For workers in normal settings, both typical and maximum scenarios show the mixer/loader and the backpack (broadcast foliar) applicator have the greatest exposure.



Accidental spills involving workers cause the greatest individual exposure. The range is from 1020 mg/kg/day for diesel oil to 0.29 mg/kg/day for picloram. No other accident for any other chemical shows greater than 0.5 mg/kg/day exposure.

Typical Public  
Scenario

Tables IV-1 through IV-5 display human margin of safety data. These tables summarize data presented in tables 5-8 through 5-23 of appendix A (risk assessment).

Comparison of estimated MOS's for typical public exposures (table IV-1) indicates that no member of the public, including sensitive individuals, should be affected by herbicides or additives proposed for use in Region 8. This generalization applies to systemic and reproductive effects.

Maximum Public  
Scenario

For the maximum public exposure scenario (table IV-2) only berry pickers who eat about 1 lb unwashed, contaminated berries are at risk. Systemic MOS's are greater than 100 for all chemicals used in this scenario except for 2,4-D (amine and ester), triclopyr (amine and ester), and 2,4-DP. For the reproductive MOS's, only berry pickers/eaters are at risk and only in areas where fruiting plants have been treated with 2,4-D ester, 2,4-DP, dicamba, and triclopyr (amine and ester) which have MOS's of less than 100. Berries sprayed with these products should not be eaten.

No public exposure for either the typical or maximum aerial application scenario has a MOS less than the 100-fold criterion other than in the case of eating foraged berries as already discussed.

Typical Worker  
Scenario

2,4-D and tebuthiuron are of concern for workers when applying herbicides with backpack sprayer (table IV-3). Each shows at least one systemic or reproductive MOS of less than 100.

Mixer/loaders and applicator/mixer/loaders are at risk of systemic toxic effects when either the ester or amine of 2,4-D is used. Also at risk are workers doing broadcast foliar treatments, and those applying the amine formulation as a cut-surface treatment. The reproductive MOS is less than 100 for ester and amine 2,4-D formulations broadcast onto leaves using backpack sprayers.

Tebuthiuron MOS's of less than 100 for reproductive and systemic effects indicate a risk of adverse effects for unprotected workers who repeatedly use it in broadcast foliar treatments with a backpack sprayer.

Without additional mitigation, 2,4-D and tebuthiuron have MOS's of less than 100 for applicators in several scenarios. Mitigation to improve MOS's can include reducing the acreage sprayed by an individual applicator, wearing

Table IV-1.--Public risk in the typical scenario; systemic and reproductive MOS values are used to compare risk levels

## SYSTEMIC MOS

2,4-D																	TRICLOPYR		
	AMINE	ESTER	2,4-DP	DICAM	DIESE	FOSAM	GLYPH	HEXAZ	IMAZA	KEROS	LIMON	PICLO	SULFO	TEBUT	AMINE	ESTER			
Dermal																			
Drift	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I			
Onsite	I	IO	I	I	I	I	I	I	I	I	I	I	I	I	I	I			
Dietary																			
Water	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I			
Fish	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I			
Meat	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I			
Vegetable	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I			
Berry pickers	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I			
Based on a systemic NOEL of:																			
(mg./kg.)	1	1	5	25	7.38	25	31	10	500	28	227	7	2.5	12.5	2.5	2.5			

## REPRODUCTIVE MOS

2,4-D																	TRICLOPYR		
	AMINE	ESTER	2,4-DP	DICAM	DIESE	FOSAM	GLYPH	HEXAZ	IMAZA	KEROS	LIMON	PICLO	SULFO	TEBUT	AMINE	ESTER			
Dermal																			
Drift	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I			
Onsite	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I			
Dietary																			
Water	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I			
Fish	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I			
Meat	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I			
Vegetable	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I			
Foraged berries	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I			
Based on reproductive NOEL of:																			
(mg./kg.)	5	5	6.25	2.5	751	500	10	50	300	751	227	50	25	20	2.5	2.5			

KEY: I = Insignificant risk (MOS exceeds 1000); **I** = Low risk (MOS is between 100 and 1000); **I** = High risk (MOS is between 1 and 100); **I** = Very high risk (MOS is less than 1); **I** = Not applicable

NOTE: Chemical names are abbreviated in tables IV-HH1 through IV-HH5 as follows: DICAM = dicamba, DIES = diesel oil, FOSAM = fosamine, GLYPH = glyphosate, HEXAZ = hexazinone, IMAZA = imazapyr, KEROS = kerosene, LIMON = limonene, PICLO = picloram, SULFO = sulfometuron methyl, and TEBUT = tebuthiuron.



Table IV-2.—Public risk in the maximum scenario; systemic and reproductive MOS values are used to compare risk levels

SYSTEMIC MOS	2,4-D														TRICLOPYR			
	AMINE	ESTER	2,4-DP	DICAM	DIESE	FOSAM	GLYPH	HEXAZ	IMAZA	KEROS	LIMON	PICLO	SULFO	TEBUT	AMINE	ESTER		
Public																		
Dermal																		
Drift	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Onsite	LO	LO	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Dietary																		
Water	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Fish	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Meat	LO	LO	LO	I	LO	I	I	I	I	I	I	I	I	I	LO	LO	LO	LO
Vegetable	LO	LO	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Berry pickers	HI	HI	HI	LO	LO	LO	LO	LO	I	LO	I	LO	LO	LO	HI	HI	HI	HI
Based on a systemic NOEL of:																		
(mg./kg.)	1	1	5	25	7.38	25	31	10	500	28	227	7	2.5	12.5	2.5	2.5	2.5	2.5
REPRODUCTIVE MOS																		
Public																		
Dermal																		
Drift	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Onsite	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Dietary																		
Water	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Fish	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Meat	LO	LO	LO	LO	I	I	I	I	I	I	I	I	I	I	LO	LO	LO	LO
Vegetable	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Foraged berries	LO	HI	HI	HI	I	I	LO	LO	I	I	I	I	I	LO	HI	HI	HI	HI
Based on reproductive NOEL of:																		
(mg./kg.)	5	5	6.25	2.5	751	500	10	50	300	751	227	50	25	20	2.5	2.5	2.5	2.5

KEY: I = Insignificant risk (MOS exceeds 1000); LO = Low risk (MOS is between 100 and 1000); HI = High risk (MOS is between 1 and 100); [X] = Very high risk (MOS is less than 1); [N] = Not applicable



Table IV-3.—Worker risk in the typical scenario; systemic and reproductive MOS values are used to compare risk levels

2,4-D																	TRICLOPYR		
SYSTEMIC MOS	AMINE	ESTER	2,4-DP	DICAM	DIESE	FOSAM	GLYPH	HEXAZ	IMAZA	KEROS	LIMON	PICLO	SULFO	TEBUT	AMINE	ESTER			
Aerial																			
Pilot	LO	LO	I	N	I	LO	I	I	I	I	I	I	I	I	LO	I			
Mixer/loader	HI	HI	I	N	LO	LO	I	LO	I	LO	I	I	I	LO	LO	LO			
Observer	I	I	I	N	I	I	I	I	I	I	I	I	I	I	I	I			
Mechanical ground																			
Applicator	LO	LO	I	I	LO	I	I	I	I	I	I	I	I	I	LO	LO			
Mixer/loader	HI	HI	I	I	LO	I	I	LO	I	LO	I	I	I	I	LO	LO			
Appl/Mix/Load	HI	HI	I	I	LO	I	I	LO	I	LO	I	I	I	I	LO	LO			
Manual ground																			
Backpack spray	HI	HI	I	N	N	LO	LO	LO	I	LO	I	I	LO	HI	LO	LO			
Basal stem	N	LO	I	N	LO	N	N	N	N	I	I	N	N	N	N	LO			
Soil spot	N	N	N	N	N	N	N	LO	N	N	N	N	N	I	N	N			
Cut surface	HI	N	N	I	N	N	LO	N	I	N	N	I	N	N	LO	N			
Based on a systemic NOEL of:																			
(mg./kg.)	1	1	5	25	7.38	25	31	10	500	28	227	7	2.5	12.5	2.5	2.5			
2,4-D																			
REPRODUCTIVE MOS																			
Aerial																			
Pilot	LO	LO	I	N	I	I	I	I	I	I	I	I	I	I	LO	I			
Mixer/loader	LO	LO	I	N	I	I	I	I	I	I	I	I	I	I	LO	LO			
Observer	I	I	I	N	I	I	I	I	I	I	I	I	I	I	I	I			
Mechanical ground																			
Applicator	LO	LO	I	LO	I	I	I	I	I	I	I	I	I	I	LO	LO			
Mixer/loader	LO	LO	I	LO	I	I	I	I	I	I	I	I	I	I	LO	LO			
Appl/Mix/Load	LO	LO	I	LO	I	I	I	I	I	I	I	I	I	I	LO	LO			
Manual ground																			
Backpack spray	HI	HI	I	N	N	I	LO	I	I	I	I	I	I	HI	LO	LO			
Basal stem	N	LO	I	N	I	N	N	N	N	I	I	N	N	N	N	LO			
Soil spot	N	N	N	N	N	N	N	I	N	N	N	N	N	I	N	N			
Cut surface	LO	N	N	LO	N	N	LO	N	I	N	N	I	N	N	LO	N			
Based on reproductive NOEL of:																			
(mg./kg.)	5	5	6.25	2.5	751	500	10	50	300	751	227	50	25	20	2.5	2.5			

KEY: I = Insignificant risk (MOS exceeds 1000); LO = Low risk (MOS is between 100 and 1000); HI = High risk (MOS is between 1 and 100); N = Very high risk (MOS is less than 1); N = Not Applicable



Table IV-4.—Worker risk in the maximum scenario; systemic and reproductive MOS values are used to compare risk levels

SYSTEMIC MOS	2,4-D														TRICLOPYR		
	AMINE	ESTER	2,4-DP	DICAM	DIESE	FOGAM	GLYPH	HEXAZ	IMAZA	KEROS	LIMON	PICLO	SULFO	TEBUT	AMINE	ESTER	
<b>Aerial</b>																	
Pilot	HI	HI	I	N	LO	LO	LO	LO	I	LO	I	I	LO	LO	LO	HI	HI
Mixer/loader	HI	HI	I	N	LO	HI	LO	LO	I	HI	I	I	LO	HI	HI	HI	HI
Observer	LO	LO	I	N	I	I	I	I	I	I	I	I	I	I	I	I	I
<b>Mechanical ground</b>																	
Applicator	HI	HI	I	LO	HI	HI	HI	HI	I	HI	LO	I	LO	HI	HI	HI	HI
Mixer/loader	HI	HI	I	LO	HI	HI	HI	HI	I	HI	LO	I	LO	HI	HI	HI	HI
Appl./Mix/Load	HI	HI	I	LO	HI	HI	HI	HI	I	HI	LO	I	LO	HI	HI	HI	HI
<b>Manual ground</b>																	
Backpack spray	HI	HI	LO	N	N	HI	HI	HI	I	HI	LO	I	HI	HI	HI	HI	HI
Basal stem	N	HI	I	N	HI	N	N	N	N	LO	I	N	N	N	N	LO	LO
Soil spot	N	N	N	N	N	N	N	LO	N	N	N	N	N	I	N	N	N
Cut surface	HI	N	N	LO	N	N	LO	N	I	N	N	I	N	N	LO	N	N
Based on a systemic NOEL of:																	
(mg./kg.)	1	1	5	25	7.38	25	31	10	500	28	227	7	2.5	12.5	2.5	2.5	2.5

REPRODUCTIVE MOS	2,4-D														TRICLOPYR		
	AMINE	ESTER	2,4-DP	DICAM	DIESE	FOGAM	GLYPH	HEXAZ	IMAZA	KEROS	LIMON	PICLO	SULFO	TEBUT	AMINE	ESTER	
<b>Aerial</b>																	
Pilot	LO	HI	I	N	I	I	LO	LO	I	I	I	I	I	LO	LO	HI	HI
Mixer/loader	HI	HI	I	N	I	I	HI	LO	I	I	I	I	I	LO	HI	HI	HI
Observer	I	I	I	N	I	I	I	I	I	I	I	I	I	I	I	I	I
<b>Mechanical ground</b>																	
Applicator	HI	HI	I	HI	I	I	HI	HI	I	LO	LO	I	I	LO	HI	HI	HI
Mixer/loader	HI	HI	I	HI	I	I	HI	HI	I	LO	LO	I	I	LO	HI	HI	HI
Appl./Mix/Load	HI	HI	I	HI	I	I	HI	HI	LO	LO	LO	I	I	HI	HI	HI	HI
<b>Manual ground</b>																	
Backpack spray	HI	HI	LO	N	N	LO	HI	HI	LO	LO	LO	I	LO	HI	HI	HI	HI
Basal stem	N	LO	I	N	I	N	N	N	N	I	I	N	N	N	N	LO	LO
Soil spot	N	N	N	N	N	N	N	I	N	N	N	N	N	I	N	N	N
Cut surface	HI	N	N	HI	N	N	HI	N	I	N	N	I	N	N	LO	N	N
Based on reproductive NOEL of:																	
(mg./kg.)	5	5	6.25	2.5	751	500	10	50	300	751	227	50	25	20	2.5	2.5	2.5

KEY: I = Insignificant risk (MOS exceeds 1000); LO = Low risk (MOS is between 100 and 1000); HI = High risk (MOS is between 1 and 100); N = Very high risk (MOS is less than 1); [N] = Not applicable

Table IV-5.—Human risk in the accident scenario; systemic and reproductive MOS values are used to compare risk levels

SYSTEMIC MOS	2,4-D														TRICLOPYR		
	AMINE	ESTER	2,4-DP	DICAM	DIESE	FOSAM	GLYPH	HEXAZ	IMAZA	KEROS	LIMON	PICLO	SULFO	TEBUT	AMINE	ESTER	
Spill onto worker	VH	VH	HI	VH	VH	VH	VH	VH	HI	VH	VH	HI	VH	N	VH	VH	
Accidental spray	HI	HI	I	LO	HI	HI	LO	HI	I	HI	I	I	LO	HI	HI	HI	
Spill into water																	
Ground	HI	HI	LO	I	LO	LO	I	LO	I	I	I	I	HI	LO	HI	HI	
Air	LO	LO	I	N	I	I	I	I	I	I	I	I	I	I	LO	LO	
Based on a systemic NOEL of: (mg./kg.)	1	1	5	25	7.38	25	31	10	500	28	227	7	2.5	12.5	2.5	2.5	2.5
REPRODUCTIVE MOS																	
	2,4-D														TRICLOPYR		
	AMINE	ESTER	2,4-DP	DICAM	DIESE	FOSAM	GLYPH	HEXAZ	IMAZA	KEROS	LIMON	PICLO	SULFO	TEBUT	AMINE	ESTER	
Spill onto worker	VH	VH	HI	VH	VH	HI	VH	VH	HI	HI	VH	LO	VH	N	VH	VH	
Accidental spray	HI	HI	I	HI	I	LO	HI	LO	I	I	I	I	I	HI	HI	HI	
Spill into water																	
Ground	LO	LO	LO	LO	I	I	LO	I	I	I	I	I	LO	LO	HI	HI	
Air	I	I	I	N	I	I	I	I	I	I	I	I	I	I	LO	LO	
Based on reproductive NOEL of: (mg./kg.)	5	5	6.25	2.5	751	500	10	50	300	751	227	50	25	20	2.5	2.5	2.5

Ground spill is assumed to be 5 gal into a pond; air spill is assumed to be 100 gal into a reservoir. KEY: I = Insignificant risk (MOS exceeds 1000); LO = Low risk (MOS is between 100 and 1000); HI = High risk (MOS is between 1 and 100); [HI] = Very high risk (MOS is less than 1); [N] = Not applicable



full body waterproof coveralls, or reducing the number of days per year an applicator sprays these two herbicides. Reducing exposure improves the MOS.

Maximum Worker  
Scenario

For workers applying herbicides in the maximum exposure scenario (table IV-4), several chemicals are of concern. Systemic MOS's for 2,4-D (amine and ester), diesel oil, fosamine, glyphosate, hexazinone, kerosene, tebuthiuron, and triclopyr (amine and ester) all have at least one worker exposure which failed to exceed an MOS of 100. Reproductive MOS's also fail to exceed 100 for some 2,4-D, dicamba, glyphosate, hexazinone, tebuthiuron, and triclopyr application methods. Remember that maximum scenarios are based on assumptions that, acting together, greatly magnify the estimate of risk (appendix A).

Accident  
Scenario

In the accident scenario several exposures are of concern (table IV-5). For systemic effects, all spills directly onto workers who did not immediately wash had either high (MOS between 1 and 100) or very high (MOS less than 1) risk levels. When a person (worker or member of the public) is accidentally sprayed during either aerial or ground spray projects, 2,4-D, diesel, fosamine, hexazinone, kerosene, tebuthiuron, and triclopyr have MOS's of less than 100. MOS's for a ground spill (5 gallons into a pond) of 2,4-D (amine and ester), sulfometuron methyl, and triclopyr (amine and ester) are less than 100 (greater risk than the standard). All MOS's projected for aerial spills are greater than 100 (less risk than the standard).

For reproductive effects, all spills onto workers have MOS's below 100 except for picloram. Granular tebuthiuron was not evaluated. For spills into water, only triclopyr (amine or ester) has a MOS of less than 100.

Herbicide  
Oncogenicity

An analysis of maximum cancer risk was performed for 2,4-DP which has positive laboratory oncogenicity studies; for light fuel oils (diesel and kerosene) which contain small amounts of materials known or suspected of causing cancer; and for 2,4-D (amine and ester formulations), glyphosate and picloram for which there is scientific uncertainty about their ability to cause cancer.

Data relating to fosamine, triclopyr, and limonene are unavailable, and imazapyr's data are incomplete. There is no evidence to show that any of the other chemicals could cause cancer: all have studies showing no effect (appendix A).

Computation of lifetime cancer risk to the public from the seven chemicals evaluated (table IV-6 and appendix A, table 5-26) showed no risk greater than 2 in 10,000,000. Compare this with the values presented in table 5-28 of the risk assessment. The worst risk estimated for any of these

Table IV-6.--Lifetime cancer risk

		2,4-D						
		AMINE	ESTER	2,4-DP	DIESE	GLYPH	KEROS	PICLO
Public								
Dermal								
Drift		L	L	L	L	L	L	L
Onsite		L	L	L	L	L	L	L
Dietary								
Water		L	L	L	L	L	L	L
Fish		L	L	L	L	L	L	L
Meat		L	L	L	L	L	L	L
Vegetable		L	L	L	L	L	L	L
Berry pickers		L	L	L	L	L	L	L
Workers								
Aerial								
Pilot		G	L	L	L	L	L	L
Mixer/loader		G	G	L	L	L	L	L
Observer		L	G	L	L	L	L	L
Mechanical ground								
Applicator		G	G	L	L	L	L	L
Mixer/loader		G	G	L	L	L	L	L
Appl/Mix/Load		G	G	L	L	L	L	L
Manual ground								
Backpack		G	G	G	NA	L	L	L
Basal stem		NA	G	L	L	NA	L	NA
Soil spot		NA	NA	NA	NA	NA	NA	NA
Cut surface		G	NA	NA	NA	L	NA	L

KEY: G = Risk greater than 1 in a million; L = Risk less than 1 in a million; NA = Not Applicable





chemicals is only 1/35th the risk of getting cancer from exposure to a single x-ray.

However, lifetime cancer risk to workers (table IV-6 and appendix A, table 5-26) is greater than 1 in 1,000,000 for workers in all categories of application of 2,4-D and for backpack sprayer application of 2,4-DP. All other evaluations for cancer potency showed risks to the worker of less than 1 in 1,000,000 (fewer than 1 in 1,000,000 workers are expected to get cancer).

#### Mutagenicity

Glyphosate, imazapyr, and sulfometuron methyl have tested negative for mutagenicity. Hexazinone, dicamba, picloram, tebuthiuron, and triclopyr are nonmutagenic in the majority of assays and pose slight to negligible mutagenic risk. Fosamine presents a very slight risk of causing mutagenic effects. No mutagenicity testing has been updated by EPA for limonene. The Food and Drug Administration, however, reports that it is "generally regarded safe" as a food additive (appendix A and table 3-6).

Both 2,4-D and 2,4-DP have shown mixed mutagenicity test results. According to Sassman and others (1984) they do not pose significant risk of human gene mutation. However, because of the mixed data on mutagenicity, both are considered to pose a mutagenic risk equivalent to their cancer potency. EPA has requested more testing.

Diesel oil and kerosene also present mixed results. Both contain small amounts of the carcinogenic compounds benzene and benzo(a)pyrene. Weeks and others (1988a) report that these compounds have the same low-order risk of causing heritable mutation as is reported for their cancer potency.

#### Bioaccumulation

Bioaccumulation is the process whereby a chemical is concentrated in tissue at a level greater than in the environment (Ottoboni 1984). To bioaccumulate a chemical must be absorbed into the body at a rate greater than it is eliminated (either through chemical breakdown or via excretion). Temporary storage in cells is not bioaccumulation. Bioaccumulation is a dynamic equilibrium process; it is not instantaneous but requires that the body be allowed time to come to an equilibrium and later to improve on that equilibrium. Bioaccumulation can occur only when the body fails to eliminate a substance.

Table 3-4 in the risk assessment shows elimination rates reported for nine chemicals: 2,4-D, 2,4-DP, dicamba, fosamine, glyphosate, hexazinone, imazapyr, picloram, and triclopyr. Elimination rates for diesel oil, kerosene, limonene, sulfometuron methyl, and tebuthiuron are not available at present. Elimination varied from 100 percent (2,4-D [rat/5 days], dicamba [rat/48 hours], fosamine



[rat/72 hours], and hexazinone [rat/72 hours] to a low of only 74 percent (2,4-DP 74-82 percent/rat/4 days). Some herbicide had not been eliminated at termination of the study for: glyphosate (8 percent/rabbit/5 days), imazapyr (13 percent/rat/24 hours), picloram (10 percent/dog/48 hours and 4 percent/unspecified test animal/24 hours), and triclopyr (9-17 percent/rat/unspecified time). The most rapid elimination reported is for hexazinone (93 percent/rat/2 hours) while the slowest is shown above for 2,4-DP.

It is unclear from the studies if these amounts of not-eliminated material represent the lowest expected level at which equilibrium is established or if further elimination continued after the termination of the studies. Classic concepts of chemical half-life in the organism and bioaccumulation as permanent storage conflict and the controversy is unresolved. Bioaccumulation, in the popular sense of continuous addition of new chemicals to an overwhelming burden, does not appear to occur with these herbicides. The bodies of test animals responded to exposure by eliminating the herbicides, not by permanently adding them to a previously accumulated stockpile of other chemicals. The limited number of exposure studies performed on field workers support this conclusion when applied to humans (appendix A).

## Synergism

Synergistic effects of chemicals are effects which occur from exposure to two or more chemicals either simultaneously or within a relatively short period. To be considered synergistic an effect must be greater than the sum of the effects of each agent alone.

The herbicide mixtures evaluated for the Southern Region's vegetation management program have not shown synergistic effects in humans who have used them in other applications.

Toxic effects of possible herbicide combinations other than those commercial mixtures registered by EPA have not been studied. Time and money normally limit toxicity testing to the highest priority -- evaluation of toxic effects of each chemical alone. Based on the limited amount of data available about effects of herbicide combinations, it is very unlikely that toxicologically significant synergistic effects could occur from exposure to two or more of the chemicals evaluated (appendix A).

There are several reasons which make the probability of the occurrence of synergism involving the evaluated herbicides extremely small. Herbicide residue in plants and soil does not persist from application to application. This results from the relatively short persistence and infrequent usage of herbicides on each site. These herbicides are rapidly excreted from the body. Exposure to two or more chemicals at the same time is likely only in cases where

those chemicals are combined in a single spray mixture. Workers having frequent contact with different herbicides are exposed to some risk of synergism. Public exposure to forestry herbicides is minimal and extremely infrequent.

The Environmental Protection Agency's guidelines for the health risk assessment of chemical mixtures (EPA 1986a) reflect the problem of missing and unavailable data with respect to synergism. While not recommending any specific process for risk assessment, they do consistently explain the use of additive models which do not recognize possible effects greater than those caused by the known effects of the chemicals in the mixture.

## **2. Effects of Prescribed Fire**

### **Brown-and-Burn**

Brown-and-burn combines the use of herbicides and fire. Herbicide is applied, vegetation is allowed to dry for 30 to 100 or more days, and then prescribed fire is used to reduce the above-ground fuel load and open the site for reforestation.



Because of concerns about the effect burning herbicide-treated vegetation might have on the health of the public and workers, two brown-and-burn scenarios are evaluated in the risk assessment (appendix A). This analysis has two purposes; to determine a sufficient interval to ensure that worker and public risk is low, and to evaluate the potential health risk resulting from wildfire occurring immediately after herbicide application.

Fuel load, smoke density, and amount of fuel consumed are based on Southern Region data for representative fuel types. Published degradation rates are used to estimate the amount of herbicide remaining intact at the time of fire. Maximum exposures are calculated for a wildfire occurring on the day of treatment.

Several assumptions were necessary due to missing or incomplete data. In all cases, assumptions were made in a conservative manner (maximum reasonable risk was chosen over lesser risk) causing estimates of risk to be high. This increases the margin of safety for workers and the public.

Threshold limit values (TLV) published by the American Conference of Governmental Industrial Hygienists (1984) are used as an indicator of the lowest acceptable level of risk from herbicide residue in smoke. TLV values indicate an acceptable level of workers' daily exposure (8 hours per day) to airborne chemicals over their careers.

Even in the wildfire scenario (wildfire occurs the same day as application) the worst exposure projected is 46 times less than the TLV. All herbicide/application-method brown-and-burn combinations evaluated after 30 days (minimum vegetation curing time period) are estimated to have significantly less risk than the TLVs allow. Seventy-four times less exposure than the TLV is the closest any typical herbicide/method combination came to the TLV. Based on this comparison there is negligible risk of negative health effects from herbicide used in brown-and-burn operations.

Bush and others (1987) measured residues released from burning herbicide-treated wood (in wood stoves or fireplaces). Herbicides evaluated were 2,4-D, 2,4-DP, dicamba, picloram, and triclopyr. Evaluation was made 4, 8, and 12 months after treatment. Residues under rapid combustion were generally much less than under slow combustion. They found that more than 95 percent of the tested herbicides were broken down by the heat of a well developed (800-1,000°C) fire. These concentrations are much less than the maximum exposure concentrations estimated for these herbicides in brown-and-burn operations (appendix A, table 5-24). Thus no significant potential exists for negative human health effects from the burning (in a hot fire) of firewood treated with these herbicides.

Bush and others (1987) also report that during slow combustion, relatively stable compounds such as 2,4-D, 2,4-DP, and dicamba were released in significant amounts. However, the levels reported were less than 1/1,000 of those judged to pose negligible risk when ingested on a daily basis.

### **3. Effects of Other Methods (General)**

People are concerned about worker health and safety for all methods used in vegetation management.

#### **Sources of Information**

Although extensive accident reporting systems exist (U.S. Department of Health and Human Services, Office of Workman's Compensation, and insurance companies), forestry-related activities cannot be isolated from data recorded in these



systems. Additionally, national summaries of accidents (U.S. Department of Labor, Bureau of Labor Statistics and others) report only numbers of accidents. Therefore, data are taken directly from Southern Region accident reports. Three years of accident reports are analyzed. A total of 622 accidents involving field personnel requiring the care of a doctor were reported during fiscal years 1984, 1985, and 1986. Of the 622 field accidents regionwide, 123 are directly related to vegetation management. The 41 Coastal Plain-Piedmont accidents directly related to vegetation management are the basis for subsequent discussion.

#### Accident Frequency

Accidents have been reported from use of manual and prescribed burning methods. No accidents have been reported from mechanical or biological methods. The only reported herbicide related accident was a worker who slipped while carrying a backpack unit and twisted his ankle.

There were no vegetation management-related fatalities from any cause reported during the 3-year period studied. During the period 1976 - 1985 two tree felling deaths and two fire-related deaths were reported which were related to vegetation management.

No data exist to determine occurrence rates of other health problems. Such things as loss of hearing due to loud tools, cancers resulting from inhaling fumes from gasoline engines or gasoline contacting skin, and secondary infection of a wound from vegetation management are not reported in a way which allows analysis. All could occur, but frequency of occurrence is unknown.

Frequency of accidents by body part affected are presented in table IV-7. In table IV-8, frequency of accidents as a function of the activity being performed is displayed. Figure IV-1 shows the number of accidents expected during a 25-year career. Overall, traumatic injuries to the back, hand and skin predominate.

Based on tables IV-7 and IV-8, and figure IV-1, vegetation management activities rank as follows (most to least risky):

1. Range management
2. Prescribed burning
3. Road maintenance
4. Site preparation work
5. Trail maintenance
6. Wildlife habitat management

High risks include: a 2 in 10 chance of back injury to range management workers (an average of 1 accident for every 5 years spent doing this type of work); an approximately 1

Table IV-7.—Body part affected: Average number of accidents per man year (40% field work) worked in several vegetation management activities in Coastal Plain-Piedmont forests; Region 8, FY'84-FY'86

	Site Prep	Pres Burn	Range	Wildlife	Road	Trail
Head, Neck, Ear, Nose	0.014					
Eye	0.005	0.009				
Skin	0.005	0.018			0.042	
Arm					0.008	
Wrist, Hand Finger	0.005	0.018		0.009	0.008	0.020
Back, Chest, Abdomen	0.002	0.018	0.104			
Legs	0.012	0.018				
Ankle, Foot, Toes	0.002					
Other						0.020
Total by Activity	0.045	0.081	0.104	0.009	0.059	0.039

Blank cells = no accidents reported during the three years being investigated.



Table IV-8.—Cause of injury: Average number of accidents per man year (40% field work) worked in several vegetation management activities in Coastal Plain forests; Region 8, FY'84-FY'86

	Site Prep	Pres Burn	Range	Wildlife	Road	Trail
Insects	0.004	0.009		0.009	0.033	
Fire		0.018				
Hand tools	0.007				0.008	0.020
Power tools						
Chain saw	0.012					0.020
Power tools Other						
Struck by Vegetation	0.012					
Slipping	0.002	0.009	0.035			
Lifting	0.002	0.027	0.069			
Dust & Debris						
Poisonous plants		0.009			0.017	
Other		0.009				
Total by Activity	0.045	0.081	0.104	0.009	0.059	0.039

Blank cells = no accidents reported during the three years being investigated.

Play It Safe. . .  
Always Wear Safety  
Equipment on the Job





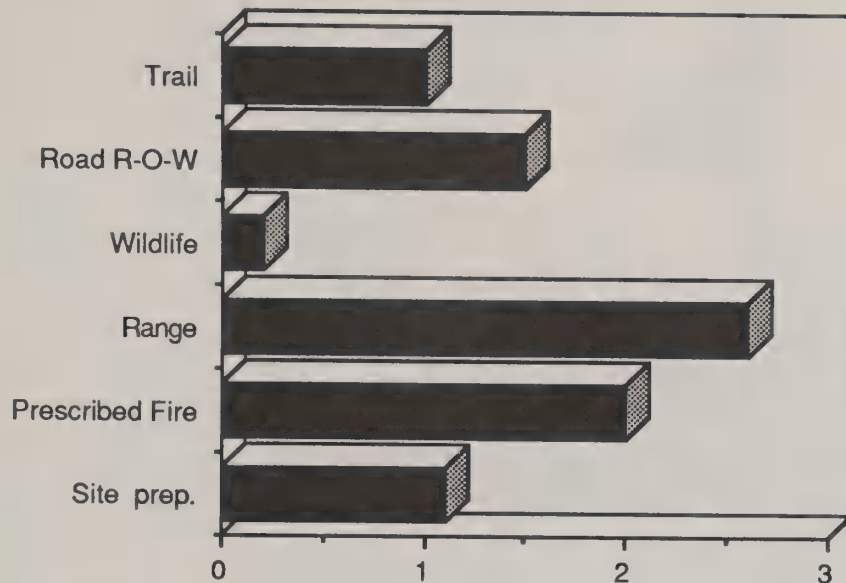


Figure IV-1.--Expected number of accidents per person during a 25-year (40% field work) career performing a single vegetation management activity on a Coastal Plain or Piedmont forest.

in 10 chance of skin problems to full-time road maintenance workers; a 4 in 100 chance of wrist, hand, or finger injury for full-time workers doing either prescribed burning or trail maintenance (an average of 1 accident per 25 years of full time field work); and, the same risk (4 in 100) of back, chest or abdomen, leg, or skin injury for technicians doing prescribed burning.

#### Severity Rating

Severity rating is based on reported costs: low (\$1 - \$100), moderate (\$100 - \$500), and high (over \$500). Severity of accidents related to site preparation is notable; 5 in 39 are in the severe category; 14 in 39 are moderately severe; and only slightly more than half are low severity accidents. Overall the ratios of low:moderate:severe accidents are similar between activities.

Table 5-28 of appendix A displays the risk of cancer or death resulting from several routine activities. Vegetation management activities contain more risk of accidental injury than these routine activities, though the consequences are normally less severe than death.

Figure IV-2 shows the average worker's risk of having an accident in a 25-year career. After correcting for the relative amounts of time spent in each activity, activities are rated (most to least risk): site preparation,

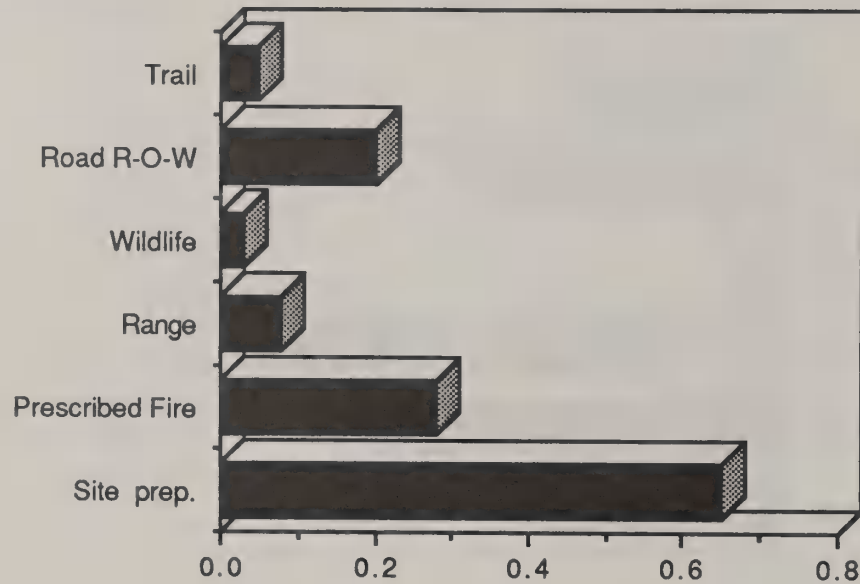


Figure IV-2.--Average number of accidents suffered by a worker working for 25 years (40% field work) in a vegetation management job with activity proportional to the average work program for Coastal Plain or Piedmont forests.

prescribed burning, road maintenance, range habitat management, trail maintenance, and wildlife habitat management (figure IV-2).

## C. VEGETATION

### 1. Effects of Prescribed Fire

#### Injury and Mortality

Prescribed fire can injure or kill vegetation. Whether or not a plant is injured or killed depends upon plant characteristics, fire type and behavior, topography, wind speed, temperature, length of exposure, and season.

Fire kills or damages plant leaves, needles, buds, stems, bark, branches, or roots. Extent of injury depends on species, age, diameter, height, and protective adaptations. Young, succulent, and actively growing vegetation is especially vulnerable (Hare 1961; Loomis 1973). For this reason, losses are generally greatest for seedlings or sprouts of any species.

Hardwood species are generally much less resistant to fire damage than are pine species (Wade 1983). In a literature review by Fennell and Hutnik (1970), that emphasized hardwood forests of eastern North America, several studies determined that within a size class yellow poplar is more resistant to fire damage than oaks. Among oak species, chestnut oak is the most resistant followed by white oak, red oak, and black oak with scarlet oak the least resistant to fire damage. Hickory, red maple, and sassafras were found to be less resistant to fire damage than oaks.

Little mortality occurs once hardwoods are greater than 3 inches in diameter at breast height (d.b.h.) (Chen, Hodgkins, and Watson 1975; Goebel, Brender, and Cooper 1967); or 4 inches d.b.h. (Johnson 1982). Most pines are rarely killed once greater than 8 to 12 feet tall or more than 2 inches in groundline diameter (Cain 1985a; Komarek 1974; Wade 1986).



Protective adaptations such as buried meristems, thick bark, protected buds, ability to resprout, and natural pruning of lower branches decrease the risk of plant injury or death (Gill 1981; Van Lear 1985). Wiregrass and curtis dropseed are herbaceous plants well adapted to fire; both have protected meristems about 1.5 inches below ground (Lemon 1949). When little damage is done to the buds of pines they can survive even severe needle loss (Wade and Johansen 1986a, 1986b).

Tree bark provides protection from fire temperatures. Species which have thicker bark are much less susceptible to fire damage (Hodgkins 1958, Langdon 1971; Wade 1986). In addition, natural pruning of lower branches of many pine species prevents low to moderate intensity prescribed fire from reaching tree crowns. Hare (1965) determined that tree species differ significantly in their resistance to damage by fire due to differences in bark insulation effectiveness and thickness. Of the species tested, when comparing trees of equal bark thickness, longleaf pine was almost twice as resistant to damage as sweetgum, black cherry, and American holly. Species resistance increases with tree diameter, due to increased bark thickness and crown height with age, and is also dependent on the intensity and duration of fire (McCarthy and Sims 1935).



Thin barked pine species such as Virginia pine and sand pine are highly susceptible to fire damage (Fowells 1965; Slocum and Miller 1953). Among hardwoods, beech, birch, and maple are thin barked species that are susceptible to basal stem injury and root damage by fire (McCarthy and Sims 1935).

Ability to resprout when the above-ground portion of the plant is killed is another important adaptation. Although pines are more resistant than hardwoods to damage from fire, if pines are top-killed (when the entire above-ground portion of the plant is killed) they do not readily resprout.

Prescribed fire increases basal sprouting of hardwood species (Augspurger and others 1986; Danielovich and others 1987; Sanders 1985). This ability decreases with increasing age and size of the hardwoods. Some hardwood species that have proven to be vigorous sprouters when topkilled by fire include oaks, black cherry, red maple, dogwood, blackgum, sourwood, and basswood (Fennell and Hutnik 1970; Henderson 1986; Teuke and Van Lear 1982).

Fire type and behavior also determine whether plants are injured or killed. Three types of fire occur. Crown fires consume the tops of trees, are very intense, and kill most vegetation. Surface fires consume woody shrubs, vines, and herbaceous vegetation. The intensity of surface fires depends upon the amount and type of fuel present as well as weather conditions. Ground fires burn below the surface and kill the roots of plants.

Surface fires are the fires manipulated for prescribed burning. Intense surface fire in areas with large amounts of available, continuous fuel create a high risk of injury or death to vegetation. According to Langdon (1981), backing fires with flame lengths of 3 feet or less develop fireline intensities to 60 Btu/ft/sec, while flanking and strip-head fires develop fireline intensities from 60 to 160 Btu/ft/sec (flame heights of 3 to 4.5 feet). Prescribed fires with flame lengths greater than 5 feet (190 Btu/ft/sec) may not be controllable. He also noted that at an intensity of 600 Btu/ft/sec (flame heights of 8.5 feet) surface fires are not generally controllable and may move into the crown fire category.

#### Season

Temperature, length of exposure, and season significantly affect plant survival. According to Hare (1961) plant tissues are instantly killed at 140°F. Johnson (1974) examined northern red oak seedling mortality after an early growing season burn in Wisconsin and found that mortality rates were related to temperatures at seedling root collars. Mortality rates were 71 percent when temperatures reached 220°F, 64 percent with temperatures between 140 to

219°F, and 19 percent when root collar temperatures were less than 140°F. Also, plants can be killed at somewhat lower temperatures when the duration of exposure is increased. The temperature the plant is exposed to depends on distance from the flames and fire intensity (Hare 1961; Wade and Johansen 1986a).

Growing-season fires injure or kill more vegetation than dormant season fires. In one study by Hodgkins (1958), burns conducted during August (growing season) killed 97 percent of 1-inch d.b.h. pines, and 60 percent of 2- and 3-inch d.b.h. pines. Burns conducted during January (dormant season) killed 41 percent of 1-inch d.b.h. pines, and no 2- or 3-inch d.b.h. pines. Wade (personal communication) found that, during the transition period between growing and dormant seasons, burns that scorch 100 percent of needles pose significant risks of mortality of slash pine only.

York and Buckner (1983) in conducting prescribed fires during May, August, and October in a 26-year old loblolly pine stand found that the early growing season burn (May) created the most intense fire and caused the most pine crop tree mortality (22 percent). However, it was the most effective in competition control (98 percent hardwood topkill) and fuel reduction (66 percent). Burns conducted during August and October were less effective due to difficulties with higher humidities and fuel moisture levels.

Hodgkins (1958) found that August burns top-killed 62 percent of 1-inch d.b.h. hardwoods, 52 percent of 2-inch d.b.h. hardwoods, and 38 percent of 3-inch d.b.h. hardwoods; while in January 46 percent of 1-inch d.b.h. hardwoods, 5 percent of 2-inch d.b.h. hardwoods, and no 3-inch d.b.h. hardwoods were top-killed. Within 2-1/2 years dense new hardwood growth replaced the top-killed individuals on all burn plots.

Lotti, Klawitter, and Legrande (1960) determined that dormant season fires did not kill rootstocks of hardwoods; top-killing occurred but the hardwoods resprouted. They found that growing season fires not only top-killed stems but also killed the roots of many hardwoods. However, Langdon (1981) found that growing season burns for 10 consecutive years were required to kill all rootstocks. Annual winter burns did little to kill rootstocks even after 30 consecutive years of burning. Growing season burns were found by Ferguson (1961) to be the most effective in topkilling stems and that 90 percent of the stems resprouted. Early and late growing season burns completely killed 10 percent of oak stems, while dormant season burns completely killed less than 2 percent of the oaks in the study area. Brender and Cooper (1968) also determined that

greater mortality to understory hardwoods occurs with growing season fires. Chen, Hodgkins, and Watson (1975) found no significant difference in understory hardwood mortality, however, between growing- and dormant-season burns. They determined that growing-season burns reduced vigor of resprouting hardwoods.

Some of these responses may be due to seasonal temperature differences. Dormant season air temperatures are generally low and more fire heat is needed to reach the lethal 140°F mark than during the growing season when ambient air temperature is quite high (Wade 1983; Wade and Johansen 1986b; Fennell and Hutnik 1970).

Mortality cannot be easily determined immediately following a fire. Some external indicators of fire injury to plants include color changes in needles or leaves, bark scorch, and possibly pitch flow (Hare 1961). Loomis (1973) indicated that accurate damage estimates in hardwoods that include both delayed mortality and obvious wound development can be made after 1 or 2 growing seasons. Injuries may only set back or weaken plants. Accurate losses from severe fire may not become apparent for several years.

Prescribed fire can cause less immediate effects than obvious plant injury or mortality. These latent effects include changes in susceptibility to insects and disease, reproduction, nutrient content, and growth response.

Plant  
Susceptibility

Fire can increase or decrease plant susceptibility to damage from insects and disease. Wounds such as fire scars increase susceptibility by weakening plants and providing entry points for insects and disease. Additional mortality can occur from stem breakage at wounds (Fennell and Hutnik 1970).

Fennell and Hutnik's (1970) review of a study by Gustafson outlines decay losses from fire as being dependent upon species growth rates, bark thickness, resistance to decay, and area of cambium killed. Hardwood species that were most severely damaged by fire through decay losses were dogwoods, sourwoods, maple, and beech; followed by hickories, blackgum, elm, ash, basswood, and butternut. Least damaged were oaks, yellow poplar, and black walnut. In species that have low resistance to decay, stems may be significantly affected above the area of obvious wounding. Berry (1982) states that in some of the more susceptible species, decay may be found several feet above a fire scar. In ash, decay can spread 1.5 inches/year starting 2 or 3 years after being wounded. In more resistant species like chestnut oak, white oak, and black oak, loss of stem quality will be minimal where wounds are less than 6 inches wide, but oaks with fire wounds greater than two-thirds the circumference of the tree



1 foot above ground level should be removed. Nelson, Sims, and Abell (1933) correlated wound size with amounts of bark discoloration. They diagramed bark burn, char, and scorch areas on yellow poplars and oaks that received a very severe early growing season fire. One growing season later they removed the bark to diagram the wounds. They found yellow poplars more resistant to wounding than oaks; and that even when high amounts of bark were discolored, larger diameter poplars developed small wounds. In contrast, scarlet oaks were least resistant and developed severe wounds with only small amounts of bark discoloration.

On a mixed pine-hardwood site, Sanders, Van Lear, and Gynn (1987) found that low intensity dormant season backing fires, with average flame lengths of 6 inches or less, caused cambium damage to 20 percent of hardwood trees 3 to 5.5 inches in diameter, 5 percent of hardwoods 5.6 to 10.5 inches in diameter, and 4 percent of hardwoods 10.6 to 15.5 inches in diameter. Hardwoods greater than 15.5 inches in diameter had no cambium damage. They concluded that low intensity prescribed fires would have little to no adverse effect on stem quality of medium to large diameter (5.6 to greater than 15 inch) mature hardwoods.

Fire decreases disease susceptibility by reducing or controlling brownspot needle blight of longleaf pine grass stage seedlings (Maple 1977), annosus root rot of loblolly and slash pine (Froelich, Hodges, and Sackett 1978), and fusiform rust of loblolly and slash pine (Lotan and others 1981; Hare 1961). The quality of oak sprouts may be improved through the use of prescribed fire by producing sprouts that originate lower on stumps; this may provide more decay resistant sprouts (Augsburger and others 1986; Roth and Sleeth 1939).

#### Reproductive Success

Success of reproductive functions such as germination, flowering, fruiting, and seed production are affected by fire. Cushwa, Martin, and Miller (1968) observed that, during simulated fire conditions, moist heat significantly increased the germination of some species of legume seed. Fire may cause the seed in the soil to break dormancy, but can reduce germination and destroy seeds when lethal plant temperatures are reached.

Garren (1943) in reviewing some of the early work of Chapman reported a great increase in germination of longleaf pine seed where prescribed burns were implemented just before seedfall occurred. Prescribed fire enhances the regeneration of yellow poplar by releasing seed stored on the forest floor (Shearin, Bruner, and Goebel 1972). Seeds of other species are not as resistant to heat damage. Among oak species, red oak and chestnut oak acorns are most resistant to heat damage, while white oak, scarlet oak, and

black oak are least resistant (Fennell and Hutnik 1970). In general, germination success is directly enhanced by the reduction of competition for light and nutrients and by seedbed preparation that exposes some mineral soil. Fire also initiates the opening of cones of serotinous pines (Langdon 1981). When overstory species are severely wounded and receive high amounts of crown damage following a fire, seed production may be restricted for several years (Fennell and Hutnik 1970).

Wiregrass has produced new leaves three days after a fire in response to early growing season burns; and in the fall following a May burn it tends to seed profusely (Lewis 1964). Early growing season burns in an Eaton and White (1960) study increased the number of sprouts and buds of lowbush blueberries. Blueberry production is stimulated and maintained by early growing season burns that are implemented prior to spring growth (Kautz 1986). Kautz states that blueberry production is highest the second year following fire, by 5 years production drops to low levels. A 2 to 3 year burning cycle was recommended to maintain high production levels.

Bracken fern (Pteridium aquilinum) is another herbaceous species that is well adapted to fire. Taylor (1985) in citing communication with Professor Robert Mount of Auburn University stated that the expansion of bracken fern in the southeast, was due to increased prescribed burning and that it effectively suppresses species such as wiregrass (Aristida stricta). Bracken fern is a serious health hazard to both man and animals. It is a carcinogenic plant that has been found to affect cows milk as well as causing the poisoning of horses and sheep (Taylor 1980). However, Preest and Davenport (1985) stated that prescribe fire can also be used to control bracken fern by timing the burn to occur when the new seasons growth reached maturity in order to take advantage of depleted starch reserves.

Johnson and Landers (1978) found negligible fruit production during the first post-burn growing season in slash pine stands 16 to 30 years old that were underburned during the dormant season. During the second growing season fruit production increased with some species such as dwarf huckleberry and runner oak attaining peak production. Three growing seasons after dormant season underburning, fruit production peaked. Stransky and Halls (1979a) found that dormant season burns produced an increase in the fruit yield of dogwood but in general produced a mixed response of fruit yields of woody plants.

#### Nutrient Content

Nutrient content of some forage species is increased by prescribed burning. Campbell and others (1954) found both protein and phosphorus are increased until May by late dormant season burns.

## Growth Response

Prescribed fire can change the environment in which plants grow. They remove litter from the ground surface, and temporarily reduce other woody or herbaceous species that compete for growing space, moisture, nutrients, and light required for optimal success in germination and establishment. Komarek (1974) noted that in the pine-wiregrass community, pitcher plants and various orchids are adapted to frequent fire and are unable to compete with litter accumulations or competition from woody species for light and nutrients.

Growth responses from burning have been both positive and negative. Early growing season burns improve height growth of longleaf pine seedlings (Grelan 1975, 1983; Maple 1977). However, in young longleaf pine saplings, Boyer (1985, 1987) found that biennial dormant or growing season burns of varying fire intensity produced from backfires, flanking fires, and strip-head fires, all reduced young longleaf pine height, diameter, basal area, and volume.

Depending upon fuel load and weather variables, low to moderate intensity fire can be expected to result in low to moderate amounts of crown scorch. Minor amounts of crown scorch, approximately 0-15 percent, were found by Johansen (1975) to enhance the growth of young slash pine. He also concluded that needle scorch of less than 40 percent of crowns did not reduce growth. Lilieholm and Hu (1987) working with loblolly pine also found that light amounts of scorch may increase growth. Waldrop and Van Lear (1984) found that moderate crown scorch did not affect the growth of unthinned young loblolly pine trees of dominant or codominant crown classes. Complete crown scorch caused 20 percent mortality of codominant and 30 percent mortality of intermediate crown classes. High amounts of scorch can be expected to produce decreases in diameter and height growth of loblolly and slash pine (Cain 1985b). In a study by Johansen and Wade (1987) slash pine with extreme amounts of crown scorch suffered no mortality during the first postfire growing season but severely scorched trees averaged 60 percent growth loss two seasons later. Slightly scorched trees averaged a 15 percent growth loss.

After a winter backing fire in a 4 year old loblolly pine stand, Waldrop and Lloyd (1988) found no loss of diameter growth, but a significant reduction in height growth occurred. During the first year after burning, height growth was reduced for each of the first three growth flushes, even when crown scorch was light. An additional loss of growth occurred during the first flush when crown scorch was heavy.



Jemison (1944) studied effects of basal wounding on the growth rate of some hardwood species and found that even severe basal wounding by fire had no significant effect on the diameter growth rate of 8 to 10 inch white oaks and black oaks, and 8 to 18 inch yellow poplars 7 to 14 years after a fire. Scarlet oak did have a reduced growth rate 14 years after wounding. Jemison also found that wounds caused only temporary obstruction to the flow of food and water in these trees, movement around the wounds quickly developed.

Community structure can be altered by temporary changes in canopy position and species composition. More long-term effects from prescribed fire occur as successional changes resulting from the interaction of species composition with fire intensity, frequency, and season over time.

Canopy  
Position

Lay (1967) noted that fire effects on understory vegetation is dependent on characteristics of understory prior to treatment. When fire is used in an understory of low-growing woody species, the amount of browse is reduced temporarily, but the quality of browse is improved. When fire is used in higher understory, canopy position is lowered as tops are killed back, but resprouting is rapid, and ultimately more browse becomes available. Chen, Hodgkins, and Watson (1975) determined that winter and summer burns reduced canopy height of woody species by more than 6 feet, and summer burns additionally reduced vigor of resprouting hardwoods. A prescribed burn study in an oak-pine site showed a decrease in the height of the understory hardwoods but an increase in the total number of hardwood stems which hindered shortleaf pine regeneration (Fennell and Hutnik 1970).

Species  
Composition

Species composition changes occur with increased fire intensity and frequency. Season of burn is also an important variable. More intense fire causes greater shifts in species composition by reducing small woody species and increasing quantities and types of herbaceous vegetation through the preparation of seedbeds more favorable to herbaceous species (Van Lear and Johnson 1983). Sanders (1985) found that herbaceous species under hardwood and pine types increased after one low intensity burn but the increase was not significant. As intensity increases, legumes and other forbs and grasses are especially favored (Cushwa and Redd 1966; Cushwa, Brender, and Cooper 1966; Czuhai and Cushwa 1968).

Single burns that occur once per stand rotation, especially of low to moderate intensity, do not significantly change species composition. One winter (dormant season) or summer (growing season) burn initially reduces hardwood vegetation, but it recovers to previous levels in 5 to 7 years (Langdon 1971). Wade and Wilhite (1981) noted woody species recovery

to nearly preburn levels by 6 years. Martin and others (1979) and Huntley and McGee (1983) also concluded that burning initially reduces woody species coverage, but woody species composition is not significantly changed.

Phillips and Abercrombie (1987a, 1987b) used early growing season site preparation burns on medium quality southern Appalachian Mountain sites to establish mixed pine-hardwood stands. After the regeneration cut, standing residual stems are felled after the initial growth period in the spring. During July these areas are broadcast burned with an intense fire over a moist fuel bed. Results indicate good growth and survival of planted pines along with good growth and form of hardwoods. Burning temporarily knocks back hardwood sprouts allowing pine seedlings to become established.

One winter burn was found by Moore, Swindel and Terry (1982a) to reduce woody species coverage, increase herbaceous species frequency and biomass, and encourage a greater variety of understory species. Prior to burning they encountered 30 woody and 37 herbaceous species, but after burning they encountered 32 woody and 61 herbaceous species. Decreases in saw palmetto and gallberry and increases in dwarf huckleberry and runner oak were also encountered.

Harlow and Bielling (1961) recommend burning cycles for specific objectives; a 3-year cycle to produce high amounts of forbs and legumes, 4 to 6 years for best understory hardwood growth and mast production, and annual burns for the greatest variety and number of plant species. Johnson and Landers (1978) recommended a 3-year burning cycle for the production of fruiting plant species for wildlife.

#### Fire Frequency

Frequency and season of burn combine to create significant impact on species composition. Frequent prescribed burns reduce woody species and increase herbaceous species (Lewis and Harshbarger 1976). Frequent burns result in less vigorous sprouts and fewer sprouts as more rootstocks are killed with each successive fire (Johnson 1982; Chen, Hodgkins, and Watson 1975; Grano 1970; Trousdell 1979).

Thor and Nichols (1974) examined the effects of annual and periodic (every 5 years) winter burns on hardwood understory species and reproduction. They found that compared with the no treatment area (8,070 stems/ac), annual (13,051 stems/ac) and periodic (12,540 stems/ac) prescribed burn areas had significantly more hardwood understory stems. Southern red oak had the greatest increase in stems per acre on both burns, followed by post oak and scarlet oak. On the no treatment area, blackgum had the greatest number of stems per acre.

Lotti, Klawitter, and Legrande (1960) determined that woody species control was minimal with annual winter burns because the rootstocks of most species survived, and once annual burns were discontinued woody species regained dominance. Van Lear and Johnson (1983) also noted that annual winter burns do not reduce the number of hardwood sprouts but only affect the size of sprouts, whereas annual summer burns effectively eliminated small woody stems. Frequent prescribed burns can effectively prevent seedling establishment of woody species. Dormant season burns are not effective in killing the roots of woody species, but frequent growing season burns are, and result in greater changes in species composition.

#### Successional Patterns

Succession refers to changes in vegetation over time. Specific patterns of change vary with site, and depend on the type of disturbance that initiates changes. Succession following prescribed fire differs from patterns generated by applying mechanical tools.

Following fire, forb dominance is followed by perennial grass dominance and ultimately by woody species dominance (Hare 1961). This change in growth forms is a commonly reported pattern, but the herbaceous community that dominates after fire is very different than the herbaceous community that is generated after major soil disturbances. Fire maintains the herbaceous layer of fire-dependent (e.g., pine/wiregrass) communities; absence of fire allows shrub invasion and consequent species loss. Understory burns in southern pine forests retard the replacement of pines by invading hardwoods (Pyne 1984). Prescribed fire in grasslands favors grasses and retards woody species encroachment.

Fire intensity, frequency, and season are some of the most important factors determining what species dominate. Fennell and Hutnik (1970), reviewing work by Ahlgren, cite 13 factors that can affect vegetation succession following fires: pre-burn condition, season, seed supply, fire intensity, ash concentration, subsequent mineral nutrition, soil moisture, rainfall, humidity, soil temperature, air temperature, animal populations, and plant competition. Frequent fires, especially during the growing season, restrict development of woody species and promote herbaceous species.

Lewis and Harshbarger (1976) reported the effects of 20 years of prescribed burning in South Carolina flatwoods. Their study looked at seasonal and frequency impacts on woody and herbaceous vegetation from annual, biennial, and periodic dormant and growing season burns. They concluded that after 20 years of burning the understory had been significantly altered. Annual summer (growing season) burns eliminated almost all shrubs, had the highest number of herbaceous species (29), and grasses became the dominant herbaceous species. Annual winter (dormant season) burns



resulted in numerous low-growing shrubs, had the next highest number of herbaceous species (26), and significantly increased the coverage of lespedeza, blackberry and sumac, but reduced gallberry, southern wax myrtle, and yellow jessamine. Biennial summer (growing season) burns were similar to annual summer burns in that most shrubs were reduced, it had the third highest number of herbaceous species (24), and of the woody species, greenbrier and sweetgum were significantly reduced while sumac was significantly increased. Both types of periodic burns occurred when 25 percent of hardwood stems reached 2 inches in diameter. Periodic summer (growing season) burns created site conditions dominated by low-growing shrubs, had an intermediate number of herbaceous species (22), and southern wax myrtle significantly increased while greenbrier significantly decreased. Periodic winter (dormant season) burns also left sites dominated by low-growing shrubs, had the second lowest number of herbaceous species (18), and sweetgum and grape significantly increased while greenbrier significantly decreased. The control area was not burned, and was dominated by low-growing shrubs. It also had the lowest number of different herbaceous species (11).

Results of this study after 30 years, summarized by Waldrop and others (1987), determined that season and frequency combine to produce significant differences in understory species composition and size class development. On periodic dormant and growing season burns, two size classes developed consisting of hardwood understory species greater than 6 inches d.b.h., and those less than 2 inches d.b.h. The larger size class represented species not topkilled at the initiation of the study. The smaller size class represented sprouts of species that were topkilled by each fire. No intermediate classes developed because burns were frequent enough to prevent growth into size classes between 2 and 6 inches. Annual winter (dormant-season) and biennial summer (growing season) burns were similar in that both had many understory woody species less than 3 feet tall which are topkilled sprouts. They differ in that more grasses occur on biennial summer burns. Annual summer burns still produced the greatest reduction in woody understory vegetation. Frequent burning killed woody root systems and promoted development of an herbaceous understory. Annual growing season burns kill root systems by gradually depleting root carbohydrate reserves. Oak root systems were the most resistant thereby giving them an advantage over other species when burning is frequent.

## **2. Effects of Mechanical Methods**

Mechanical methods can injure or kill vegetation. Mechanical tools, in increasing order of intensity, are: mowing, chopping, shearing, scarifying, ripping, piling, raking, disking, and bedding. The use of mechanical methods can be severely restricted due to seasonal impacts. In the Coastal Plain/Piedmont, the use of heavy mechanical equipment predominately occurs during the driest months of the year (June through September).

## Injury and Mortality

Shearing and mowing tools cut only the above ground portions of plants. They effectively kill species, such as most pines, that do not have the capacity to resprout. Piling tools are normally used after stems have been sheared or manually cut. Mortality is low as long as plants are not uprooted.



Chopping cuts above ground stems, but also severs plant roots or rhizomes (horizontal stems below ground). Research has shown that high mortality from double chopping occurs to wiregrass, saw-palmetto, runner oak, ground blueberries, and dwarf huckleberry (Lewis, Tanner, and Terry 1987; Lewis 1972, 1980a; Moore 1974; Yarlett 1965). Gallberry, due to its ability to resprout, is only injured and quickly recovers, while blackberry and wax myrtle stems increase with chopping (Lewis, Tanner, and Terry 1987).

Significantly higher injury and mortality occur with more intensive raking, disking, bedding, ripping, and scarifying tools because more rootstocks are affected. Schultz (1976) found that disking or bedding treatments significantly reduced saw-palmetto, gallberry, and curtis dropseed and that gallberry rapidly sprouts back from buried stems and roots.

Mechanical methods effectively reduce or control woody and herbaceous competition, permitting increased survival and growth of planted pines and hardwoods.

## Competition

On a lower piedmont site, Edwards (1986) observed that more intensive treatments were more effective in reducing competition, producing greater seedling survival after the first growing season and the best height growth responses at the end of two growing seasons. Slay and others (1987) in

North Louisiana did not find significant differences in survival; all treatments produced acceptable survival. They did, however, note the relationship between amount of competing vegetation reduction and seedling growth response. Treatments that are combinations of tools are generally more effective in competition control. Stransky and Halls (1981) compared burning, chopping and burning, and a treatment consisting of shearing, raking, burning, and disking on east Texas loblolly pine-shortleaf pine-hardwood sites. The latter, which is the most intensive, provided the greatest amount of competition control and produced significantly greater tree growth than the other two treatments. Chopping and burning produced the next highest response, followed by the burning only treatment.

#### Growth Response

Outcalt and Brendemuehl (1984) found that chopping significantly increased diameter growth, and, to a lesser extent, also increased height growth of sand pine.

Increases in seedling survival and growth have been reported for scarifying tools through the creation of improved microsites, providing nutrient pools near the seedlings, and the control of competing herbaceous vegetation (Alm, Long, and Eggen 1988).

In one study, ripping caused no effect on first or second year survival of loblolly pine, but provided increased soil moisture in the upper 4 inches of soil. By the end of two growing seasons, ripping increased total seedling height by 10 percent (Wittwer, Dougherty, and Cosby 1986).

Stafford, Torbert, and Burger (1985) showed significant loblolly survival, height, and diameter growth responses with shearing, raking, or disking treatments. In their study all disking treatments increased early growth from what they attributed to relieving compacted soil conditions.

Disking has also improved survival and growth of planted hardwoods. On bottomland hardwood sites in western Mississippi, Kennedy (1981a, 1981b) compared mowing and disking treatments with a no treatment control plot for sycamore, green ash, nuttall oak, sweet pecan, cottonwood, and sweetgum. He found that disking provided hardwoods with additional water and nutrients by controlling vines and weeds. Seifert, Pope, and Fischer (1985) compared disking, disking and bedding, and no treatment for planted swamp chestnut oak. Survival did not differ between the two methods, but survival with no treatment was 15 percent lower than either method. Disking has also doubled the amount of survival, and increased height growth of cherrybark oak by 18 percent (Woodrum 1983).



Outcalt (1983) found that disking increased slash pine diameter, height, and volume growth. Studies by Tiarks (1983), and Mann and Derr (1970) have shown similar positive growth responses for loblolly and slash pine.

Bedding tends to produce even more dramatic growth responses than disking. DeWitt and Terry (1983) documented significant loblolly growth response to shearing, piling, and bedding treatments. Bedding was especially effective in reducing competition by cutting and exposing the roots of woody species. In Pritchett's (1979) study, bedding resulted in a four foot height growth advantage over a burn only treatment, while disking produced a one-foot height advantage over the burn only treatment. Survival on bedded sites was three times better than those which were burned only, which Pritchett felt was due to greater competition control. Mann and Derr (1970), McKee and Wilhite (1986), Gent and others (1986), and Baker (1973) also documented increased growth responses from bedding on loblolly and slash pine. However, Derr and Mann (1977) noted increased seedling mortality on bedded sites when planting occurs before bed settling, and they also encountered an increased incidence of fusiform rust on bedded plots.

Growth losses can occur from piling and raking treatments when nutrient displacement occurs. Swindel, Conde, and Smith (1986) found that tree height, basal area, and volume were smaller for trees not growing near or adjacent to windrows. They attributed this to the accumulation of soil and litter in the windrows.

Lennartz and McMinn (1973) reported on the effect of low (burn only) to high (complete clearing) intensity site preparation treatments on slash pine height growth. Responses to mechanical treatments, though declining over time, were still significant 10 years after the initial treatment. However, several studies have shown that by 13 to 15 years the advantages provided by low to high intensity mechanical treatments are no longer significant for pine diameter, height, or volume growth (Tiarks 1983; Haywood 1980, 1983; Outcalt 1984; Buford and McKee 1987).

#### Species Composition

Shifts in species composition are caused by use of mechanical methods. Mechanical treatments reduce woody species and increase herbaceous species temporarily. In general, the more intensive a treatment is the greater the shift in species composition. Lewis, Tanner, and Terry (1987) noted that mechanical methods reduced woody species coverage but that overall species composition was not affected. Miller (1980) also determined that while tree, shrub, and vine species were 55 percent smaller on windrowed areas compared to chopped areas, there were no differences in overall species composition. Both areas had approximately 118 herbaceous and 15 grass species.

Comparing burning and disking treatments Buckner and Landers (1979) determined that herbaceous annuals and perennials are favored by disking. After one growing season single disked areas had better herbaceous growth and production than double disked areas, but during the second year the double disked areas yielded more herbaceous food plants and seed than even annually burned plots.

#### Successional Patterns

Following mechanical treatments sites are dominated by herbs, which eventually are replaced by invading shrubs and trees. Herbs that dominate after soil disturbing activities are most likely to be ruderal species with characteristics that allow them to colonize open sites. These characteristics include abundant seed production, rapid growth rates, short life cycles and easily dispersed seeds. Conversely, species typical of sites without soil disturbance tend to grow more slowly, produce seed less predictably, and not disperse their seed widely. The time required for woody plant recovery ranges from 5 to 10 years, and varies directly with the intensity of mechanical treatment.

Research has shown that following harvest and site preparation by low to high intensity mechanical methods, herbaceous species temporarily increase while woody species temporarily decrease. One study by Conde, Swindel and Smith (1983a) showed that by the second year after harvest and site preparation by chopping and bedding, herbaceous species dominated the site but woody species were beginning to recover. Their conclusions were based on measurements of woody and herbaceous species cover, frequency, and biomass. A more intensive mechanical treatment consisting of prescribed burning, shearing, piling, disking, and bedding, produced similar results but succession was set back further (Conde, Swindel and Smith 1983b). Woody species recovery was slower but after 2 years it was beginning to increase. After 5 years the lower intensity treatment area (chopping, bedding) was again dominated by woody species while succession on the higher intensity treatment area (burning, shearing, piling, disking, bedding) was proceeding towards a woody species community but was still dominated by herbaceous species.

Vegetation impacts from burning, chopping, shearing, and raking were analyzed by Stransky, Huntley, and Risner (1986). They found that 1 year after mechanical site preparation herbaceous species increased and woody species declined, with less decline on chopped than sheared and raked areas. After 3 years the herbaceous species peaked and woody species were almost back to pretreatment levels. During the 5- to 10-year period after treatment, herbaceous species declined as they were shaded out by the pine and hardwood canopy closure. Ten years after the treatments, the woody species had fully recovered.

Mechanical treatments are more effective than other methods, such as fire, in reducing woody species (Stransky, Huntley, and Risner 1986; Moore, Swindel, and Terry 1982b) and mechanically treated areas are slower to recover to pretreatment levels than other methods (Lewis, Tanner, and Terry 1987).

### 3. Effects of Herbicides

Herbicides are designed to injure or kill plants. The effect of a specific herbicidal treatment, however, is the result of many interacting factors including: initial vegetation onsite; selectivity of the herbicide and application method used; pattern in which the herbicide is applied; biochemical effects of the herbicide on vegetation; and timing of the treatment (Gjerstad and Nelson 1986; Norris 1981; Smith 1966). General discussion of vegetation effects is found below; further discussion of tools and herbicides is found in chapter II. Unless otherwise noted the following information about uptake, movement, and effectiveness of herbicides is from the 5th Herbicide Handbook of the Weed Science Society (1983).

Herbicides can be broadcast or more selectively applied. Broadcast application achieves uniform distribution of herbicide. Aerial and ground-mechanical applications of granular or liquid products are generally broadcast. Broadcast application is commonly used for site preparation, release, and rights-of-way maintenance (Cantrell 1985). Selective methods allow for incomplete area coverage or application to specific targets. Hand applications are generally target or spot specific (Williamson and Miller 1987). Directed foliar sprays, cut-surface treatments, and basal stem treatments are target selective; spot around and basal soil spot treatments are less so; grid soil-spot, banded foliar, and many herbaceous weed treatments are the least target specific of the selective methods. More selective application patterns have less risk of affecting non-target vegetation than broadcast applications. They are commonly used for site preparation, release, precommercial thinning, ROW maintenance, wildlife habitat improvement, and weed control in recreation areas.

### Injury and Mortality

Rates of uptake and time until the first effects show vary with species, product, and environment (Gjerstad and Nelson 1986; Norris 1981). Dicamba, fosamine, 2,4-D and 2,4-DP are taken in through leaf, stem and root tissue (Kitchen, Rieck, and Witt 1980; Weigel, Beyer, and Riggelman 1978). Imazapyr and picloram enter either through the roots or leaves. Hexazinone and tebuthiuron are taken in primarily through the roots with some entering through leaves (McNeil, Stritzke, and Basler 1984). Sulfometuron methyl primarily enters through leaves, but there is some root uptake. Glyphosate and triclopyr enter primarily through leaves.

Some plant surfaces are designed to selectively protect the plant (bark on stems, wax on leaves) (Norris 1974).



Penetration of these surfaces is enhanced by using additives such as diesel oil, kerosene or limonene. Thickness of bark on stems or wax on leaves influence the effectiveness of a herbicide treatment even when an additive is used.



Once a herbicide is taken into a plant, it may move through plant tissues. Many herbicides concentrate in growing tissues and disrupt normal functioning. Some disrupt photosynthesis (glyphosate, hexazinone, and tebuthiuron), some interfere with amino acid synthesis (imazapyr) (Peoples 1984), and others (dicamba, fosamine, picloram, sulfometuron methyl (duPont 1982), triclopyr, 2,4-D, and 2,4-DP) interfere with growth processes such as cell enlargement, cell reproduction, or bud formation and enlargement.

Translocation of herbicides in the plant generally follows the normal food movement system. Dicamba, glyphosate, picloram, and triclopyr are translocated up and down in plants, accumulate in plant roots or root collars, and effectively suppress sprouting from stumps (Lewis, Zedaker, and Smith 1984; Troth, Lowery, and Fallis 1986; Warren 1980). Fosamine inhibits bud formation and growth, and is practically immobile; thus it can be used to chemically prune only a part of a plant (Coupland and Peabody 1981).

Some herbicides are broken down by plants. Limited information is available about the chemical breakdown products and their effects (Chrzanowski 1983; McNeil, Stritzke, and Basler 1984; Sung, South, and Gjerstad 1985). Primary concern thusfar has been to determine and report what these degradation products are and how rapidly they are further decomposed. Herbicidal, toxicological, or biochemical properties are, as yet, virtually unreported.

Plant  
Susceptibility

Effectiveness of herbicides varies among plant species. Dicamba, 2,4-D, 2,4-DP, picloram, fosamine, and triclopyr are used to control woody species and broadleaf weeds. Glyphosate, hexazinone, imazapyr, and tebuthiuron are effective against grasses, woody species, and broadleaf weeds. Sulfometuron methyl is used primarily to control weeds and grasses.

Some herbicides are essentially ineffective against certain plants. Though effective against most hardwood species, hexazinone has virtually no effect against yellow-poplar. Imazapyr gives limited control of locust, redbud, blackberry, and most legumes.

Some plants or groups of plants are extremely difficult to control. Glyphosate is fairly effective against sedges; picloram and dicamba are commonly used to control kudzu. Tebuthiuron is also used for kudzu control on non-forest sites (Miller 1986).

Effects of herbicides also depend on season of application (Gjerstad and Nelson 1986; Norris 1981). Fosamine, which blocks spring bud break, is a very slow acting herbicide which is generally fall-applied; effects are usually not seen until the next spring. Spring or early summer foliar applications of dicamba, 2,4-D, 2,4-DP, and hexazinone are effective in controlling many woody species while application of picloram, sulfometuron methyl, tebuthiuron, or triclopyr is done in the spring, summer or fall (excluding droughty periods). Successful bracken control is critically dependent on the timing of herbicide application (Robinson 1985). Cut surface treatments are made throughout the year.

Several herbicides are soil active; once in the soil they can be taken up by plants. Hexazinone and tebuthiuron are currently produced in formulations labeled for soil application. Dicamba, imazapyr, picloram, sulfometuron methyl, triclopyr, 2,4-D, and 2,4-DP also have some soil activity. Non-target plants may be affected if they are within the treated area or if their roots grow into it. Hexazinone remains active in the soil for 2 weeks to 6 months; imazapyr and tebuthiuron remain active longer (appendix A). Labels of products containing tebuthiuron carry the warning that the product is "...a very active herbicide which will kill trees, shrubs and other forms of desirable vegetation having roots extending into the treated area." (Elanco 1986). This effect persists significantly longer than a growing season in the South but less than the five years reported in arid climates.

Reproductive  
Success

Herbicides evaluated do not appear to affect seed biochemistry or germination rates (Prasad 1984). Soil active herbicides do, however, affect young seedlings emerging from seeds in treated areas. Persistent soil-active herbicides can cause a temporary shift in types of vegetation growing on a site.

Successional  
Pattern

Broadcast application of a herbicide selective to woody species generally results in a vegetation cover composed of grasses, sedges and forbs. Species' resistance to herbicide complicates this generalization. Target specificity of herbicides will influence the species composition of residual vegetation on a site.

Selective applications permit significant manipulation of vegetation. Species which are potential hazards due to height, noxious nature, or other consideration can be selectively controlled. Depending on the selection process, selective stand treatment can be used to favor almost any species.

Herbicidal site-preparation, broadcast or more selectively done, is reported as having beneficial effects on both height and diameter growth of hardwoods and conifers (Byrd and Foster 1982; Holt and Nation 1974).

Herbicidal TSI treatments (pine or hardwood stands) to eliminate competing species improves stand vigor and quality (Miller, Wray, and Mize 1987). Haines and Davey (1979) report that in a study to measure growth response (as total loblolly pine biomass produced) the most pronounced treatment effects were obtained with the use of herbicides. Cain (1985a) reported that chemical treatments were more effective than prescribed burning for reducing hardwood density in a stand being managed for pine sawlog production and that the reduction was still evident 23 years after treatments were discontinued.

Release treatments which involve herbicides, either broadcast or more selectively applied, are reported to be highly effective in improving growth of desired pine or hardwoods (Knowe and others 1985; Wendel and Lamson 1987; Zutter and others 1987). Herbaceous weed control, by increasing water and nutrients available to pine seedlings, is reported to generate significant increases in survival and growth of planted pine seedlings (Nelson, Zutter, and Gjerstad 1985; Whipple 1962). Herbicidal release can be the difference between successful or unsuccessful pine planting (Wilson n.d.).

Sterrett and Adams (1977) reported that 3 years after herbicide release treatments pine growth had improved, and, although numbers of some (non-pine) species had declined



there was a striking increase in the number of individuals of some species present, as well as the number of species present on the treated area. Scifres and Koerth (1986) report that, though initially affected, diversity and coverage by forbs were virtually unaffected 1 year after tebuthiuron application.

The chief difference noted between forest and ROW sites is frequency of treatment. On forest sites, herbicide treatment is done to temporarily favor a species or group of species at a specific point in its life cycle. Due to physical requirements, ROW's are maintained (by repeated management activity) in an early successional stage. Type of plant cover varies greatly depending on the vegetation management technique used (Bramble 1962). Broadcast herbicide application permits maintenance of a low grass, forb and sedge community; more selective application permits maintenance of a slightly taller, shrubby community. For powerline ROW either broadcast or selective treatment may be used. Along roadsides and gas pipeline ROW's broadcast application is generally used to maintain a low-growing, grassy community. However, selective application may be used to favor species such as wildflowers.

There is no evidence that repeated typical applications of a herbicide in ROW settings cause permanent effects on succession. Normal succession resumes within one to three years of last application of herbicide (Bramble and Byrnes 1982).

Information about additional effects of herbicide use in an environment already affected by industrial pollution, agricultural pesticide usage, and automobile emissions is unavailable. Herbicides are applied to individual even-aged stands only one to three times (stand establishment and stand improvement activities) during the 60 or more years they are grown. Herbicide use rates in most Forest Service applications are also very low relative to agricultural or other uses. However, managing uneven-aged stands of pine will require that herbicides be used more frequently to permit establishment of pine reproduction. A 5- to 10-year treatment cycle (which may include fire, manual or mechanical tools) will be necessary (Wenger 1984).

#### **4. Effects of Biological Methods**

##### **Injury and Mortality**

Cattle grazing can injure or kill vegetation. Grazing also causes changes in plant growth response, and shifts in species composition.

Cattle consume pine and hardwood foliage, and young new shoot and twig growth. Amounts consumed are minor since herbaceous species comprise the bulk of their diet. Plant mortality from direct consumption is low because rootstocks are normally not affected, and most woody and herbaceous species resprout.

Damage to pine and hardwood seedlings occurs from browsing and trampling. In sapling and larger-sized stands, damage occurs from the browsing of lower branches, and by the breaking of lower branches by leaning or rubbing (Lewis, Tanner, and Terry 1987).

Lewis (1980b) simulated cattle injury to planted slash pine and found most mortality occurs 1 to 2 months after an injury. Pearson, Whitaker, and Duvall (1971) found that 80 percent of plant mortality occurs within a few months after planting, and once herbaceous species are available cattle stop browsing the pines. Most planting occurs during the dormant season (December through March) when most herbaceous forage species are unavailable to cattle. The greatest mortality of planted seedlings occurs on heavily grazed sites; light to moderate grazing seedling losses are not significant (Grelen, Pearson, and Thill 1985; Pearson, Whitaker, and Duvall 1971; Clary 1979). Considering that heavy grazing is required to achieve biological vegetation control objectives, significant losses from injury and mortality are expected.

#### Growth Response

Effects on growth responses are mixed. Pearson, Whitaker, and Duvall (1971) found no significant impact from grazing on growth of seeded or planted pine through 5 years of age. However, measurements taken by Grelen, Pearson, and Thill (1985) on the same site at age 18 showed significantly larger tree diameters on heavily grazed plots compared to ungrazed control plots. Height growth and volume were not affected. Herbaceous forage yields monitored over a 10-year period were not significantly impacted by heavy utilization intensities as high as 60 percent of the current year's growth (Pearson and Whitaker 1974a, 1974b; Clary 1979).

#### Species Composition

Shifts in species composition occur from heavy grazing. Herbaceous species which comprise the majority of preferred cattle feed are most affected. Grazing can increase forbs and decrease grasses. As grazing intensity increases, species such as pinehill bluestem and panicums decrease and carpetgrass increases (Clary 1979; Pearson and Whitaker 1974a). Woody browse species do not appear to be significantly affected (Pearson and Whitaker 1974b; Clary 1979).

Heavy grazing intensities utilized to achieve site preparation or release objectives when used for more than one or two consecutive growing seasons will change species composition. The longer areas are intentionally overgrazed, the higher the risk of long-term shifts in species composition.

## **5. Effects of Manual Methods**

### **Injury and Mortality**

Manual methods can injure or kill vegetation by completely severing or girdling woody stems. Plants such as most hardwood species and woody shrubs that resprout are usually injured. Plants, such as most pine species, that do not resprout are usually killed.

Non-target vegetation can also be injured or killed when woody shrubs or trees being felled fall onto or cover other stems. Loss of stems selected to remain can be significant. Bernstein (1981) found that 31 percent of conifers in a release project were damaged or covered by slash. A significant risk of injury and mortality in young pine or hardwood plantations exists from the buildup of hazardous fuels from manual release and precommercial thinning projects. This risk is highest for precommercially thinned stands approximately 1 to 6 months after project completion.

Wounds caused by felling woody shrubs or trees onto remaining stems create entry points for insects and disease organisms which may eventually cause stem mortality. In the upper piedmont of Georgia, Miller and Phillips (1984) observed that stumps from chainsaw treatments for hardwood site preparation produce sprouts with higher risk of decay and poorer anchorage than mechanically sheared stumps, because the sprouts originate higher on the stumps and closer to cut surfaces.

Incomplete severing or girdling of target vegetation might not cause immediate mortality but weaken individual stems and cause mortality several seasons later. A study by Cody and Burns (1976) showed that a single chain saw girdle was effective in removing unwanted hardwood vegetation (90 percent mortality), but mortality occurred over four growing seasons.

### **Growth Response**

Manual cutting tools are highly selective and can be used year round on all landtypes, but repeated treatments, either annually or even more frequently, may be necessary to adequately control woody competition (Lowery 1986). Species which resprout can quickly reoccupy treatment sites, and height growth of sprouts can exceed that of natural and planted seedlings (Miller and Phillips 1984). On moderate to highly productive sites several repeated treatments may be needed to successfully release desired species.

Long-term effects of manual methods on vegetation are negligible. Sprout growth and crown closure rapidly reoccupy the site.

## **D. WILDLIFE**

Effects of vegetation management on animals can include physical injury or mortality, and short-term and long-term habitat alteration.



Injury and  
Mortality

Death may result from the effects of herbicides or prescribed fire, or from mechanical, manual, or biological treatments applied to a site when animals are present.

Habitat  
Alteration

Wildlife habitat is the food, water, and cover that an animal needs to survive. Each species is adapted to a unique arrangement of these elements. The distribution of different ecological types and progression of successional stages through time provides these habitats. As habitat changes, so does the variety and abundance of wildlife species.



Vegetation management affects each species' habitat in a different way, benefiting some and harming others. For instance, when natural succession is retarded, species which need early successional stages usually benefit. Vegetation management also affects wildlife when it influences a key habitat element such as food or a place to breed. For example, site preparation may increase or reduce the number of snag trees available for cavity nesting birds. Or numbers of soft-mast producing plants may be reduced by application of herbicides or increased by a mechanical method which encourages sprouting, such as chopping.

Structural diversity of vegetation is probably the most important factor in determining wildlife species composition and abundance (Harris, Hirth, and Marion 1979). Prescribed underburns, for example, alter vegetation structure and composition by reducing woody understories and increasing ground vegetation. This action benefits species such as white-tailed deer by providing more desirable food sources but may degrade the habitat of songbirds like hooded warblers (Wilsonia citrina) which use woody understory.

To keep the effects of vegetation management in perspective, it should be stressed that most vegetation management occurs after habitat has already been substantially altered by timber harvest or regeneration. Silvicultural system (intermediate thinnings, or final harvest; distribution, size, and shape of regeneration areas; rotation age; retention of old-growth), streamside management zones, erosion control, road construction, and other management practices prescribed in Forest Land and Resource Management Plans (and outside the scope of this document) are likely to have a greater impact on wildlife abundance and species composition. Harvest of a mature pine stand, for example, tends to have a more significant effect on wildlife species occupying the site than subsequent site preparation or intermediate treatments which interrupt or accelerate the process of succession.

When vegetation management practices in combination with timber harvest and other management practices are applied in a forest, a variety of vegetation types and structure results. Over time, a mosaic of types is spread across the forest landscape and habitat is provided for many different species of animals. This cumulative effect increases over-all or "among-stand" wildlife diversity even though "within-stand" diversity for a particular site may decrease.

Many treatments using a single tool (pine release by herbicide, for example) which are made only once during a rotation cause few long-term effects. More long-term effects occur when more than one method (such as chainsaw, stump-spray, and prescribed burn) are applied during a single treatment. When this occurs only once in the life of the stand, long-term impacts are not as likely as when stands are treated repeatedly. An example of multiple and repeated treatments is site preparation by KG blade, windrow, and prescribed burn followed by herbicide release at age 3, and prescribed burning on a 5-year cycle beginning at age 10. This sort of periodic treatment is effective in relegating many hardwoods to the understory. Although many hardwoods survive, many important species do not reach the age or size necessary for mast production or creation of nest cavities. In addition, periodic burning tends to remove downed woody material which provides habitat for reptiles and amphibians and eliminates accumulations of tops and brush which are used for cover by species like cottontail rabbits (Sylvilagus floridanus). However, burns also provide a continuing source of new den sites, downed vegetation, and brushpiles when living trees are killed by fire.

More research is needed into long-term effects on animals associated with plant communities treated with specific combinations of herbicides and periodic fire. Ongoing research and vegetation classification and inventories planned for the Southern Region will help fill some of these gaps.

## 1. Effects of Herbicides

### Source of Information

Information sources for assessing the risk of direct toxic effects to wildlife and aquatic animals are the same as for the human health risk assessment discussed in section B of this chapter. Three sections of the risk assessment apply to the analysis of risk to wildlife and aquatic species:

- Section 6 (the hazard analysis) documents basic toxic properties of the chemicals.
- Section 7 (the exposure analysis) documents probable exposures to these chemicals of terrestrial animals such as mammals, birds, reptiles, and invertebrates; and aquatic animals such as fish, invertebrates and amphibians.
- Section 8 (the risk assessment) combines predicted hazards and exposures, and estimates danger to these animals.

Unless otherwise noted, information presented here is derived from the Risk Assessment (chapter 6-8, appendix A). Literature citations for specific points are found in that appendix.

### Hazard Identification

Hazard is evaluated based on dose/time relationships. These relationships and their effects are the same as for human health: acute toxicity, subchronic toxicity, chronic toxicity, mortality, and organ effects.

### Exposure and Dose Response

Exposure considerations include where the animal lives, how it moves and feeds, external characteristics of the animal (hair, feathers, scales), rate of herbicide application, size of treatment area, the way the herbicide was applied, and physical characteristics of the herbicide (persistence or drift potential). Exposure is estimated for three different situations:

The **typical** situation (the "realistic" scenarios in the wildlife sections of the risk assessment) estimates the average exposure of terrestrial and aquatic animals that may be reasonably expected during routine operations.

The **maximum** situation ("extreme" scenarios in the wildlife sections of the risk assessment) estimates the worst realistic exposures to terrestrial and aquatic animals when highest rates of herbicide are applied in an area.

An **accident** situation estimates the exposure of terrestrial and aquatic animals which might result from a spill of cans from a truck or a helicopter tank dump into water.



Exposure  
Information

Risk is a function of dose, which is critically dependent on many interrelated factors. Changing any of the factors modeled when predicting risk will change the dose and the potential effects on animal health. Estimates were also made of indirect exposures due to surface, subsurface, or airborne movement of the herbicides and additives in the environment.

Because toxicological data are unavailable for most species occurring in the Coastal Plain/Piedmont, a set of species was chosen to represent animals from a variety of habitats and dietary needs. Terrestrial mammals, birds, amphibians, reptiles, and invertebrates, and fish and aquatic invertebrates were selected. Since laboratory tests are not normally done on wildlife species, it was necessary to evaluate several of the representative species by using data for similar animals for which tests have been done.

Terrestrial species: Herbicide skin contact, inhalation (breathing), and ingestion (eating) are the exposure routes evaluated. Exposure rates were estimated for typical and maximum application rates for ground applications.

The typical setting assumes that animals seek cover during a mechanical application and exposure is limited to contact with and ingestion of herbicide on or in leaves. The maximum case assumes that the animal is sprayed. In both cases, mammals and birds are assumed to ingest herbicide while preening after touching treated vegetation.

In the typical case, the amount of herbicide-contaminated food is taken to be a percentage of the diet (based on the size of the animal's feeding territory). In the maximum case all food is assumed to be contaminated.

Total exposure is estimated by adding exposure by all routes (appendix A, section 7).

Aquatic species: Exposure is assumed to occur from herbicides that drift off-site during mechanical ground applications. Estimates of typical exposure are made using typical application rates and a 66 foot buffer between application site and the water. Estimation of maximum exposure is made using maximum application rate information and assuming only a 33-foot buffer.

Accident: Two aquatic accident scenarios are evaluated. In one, a single 5-gallon can (the largest can normally carried to the field on a pickup truck) of herbicide spilled into a pond; in the other, an emergency requires a helicopter pilot to dump a full 100-gallon tank load (the average tank size for helicopter applications) of chemical into a reservoir. Values of 5 gallon/pond and 100 gallon/reservoir are

converted to parts per million in table 7-6 of the risk assessment (appendix A). In these cases, exposure through breathing (gills in contact with contaminated water) is more significant than in the terrestrial case or even for the maximum aquatic case.

#### Risk

Calculations of risk are based on a theoretical dose to animals in each typical, maximum, and accident situation. Risk is evaluated using EPA standards (EPA 1986a). Predicted risk is compared with published standards to see if the herbicide or additive poses a greater or lesser risk. Practices which reduce risk to a level lower than the standard are noted as management requirements or mitigating measures in chapter II.

#### Inert Ingredients

See discussion in chapter IV, section B.

#### Data Gaps

When assessing herbicide effects on wildlife, we face an overwhelming number of species with data gaps and inconsistencies in data. Regulatory requirements (40 CFR 1502.22) described in the human health section (Chapter IV, Section B) are addressed in the wildlife risk assessment (appendix A, sections 6-8). Response varies greatly among species, and differences among species are significant even within the same taxonomic grouping such as bird or fish. Ideally, to analyze effects on a species, data should be from tests on that species or a closely related one. Table 8-15 in the risk assessment (appendix A) summarizes data gaps for several species of aquatic animals.

Data gaps which result in uncertainty about reasonably foreseeable significant adverse animal health effects include the following:

- Basic data about acute, subchronic and chronic toxicity are lacking for many animal groups; species-specific information are generally unavailable. Some acute toxicity data are available for mammals but are unavailable for several chemicals for birds, insects, fish, aquatic invertebrates, and amphibians.
- Data on animal exposure to herbicide are generally unavailable. Dermal penetration rates, risk of exposure, and probable rate of exposure are not available.
- Field studies on chemical residue levels in or on plants in treated areas are lacking for most herbicides.
- Carcinogenic and mutagenic potential are unreported for most chemical/animal groupings.

- Data on synergistic effects of herbicides and inert ingredients on wildlife are not available.
- Data on cumulative effects of herbicides on wildlife are unavailable.
- Data concerning relationships between specific chemicals and individual species' habitats are, for the most part, unavailable.

Filling data gaps is a extremely expensive process; individual tests cost between \$50,000 (mutagenicity tests, etc.) and \$2,500,000 (chronic toxicity tests, oncogenicity tests, etc.). As in the evaluation of human health effects, the Forest Service considers the accumulated costs of filling all of the data gaps prohibitive. Modeling is done to overcome missing or unavailable data.

The analysis of missing and incomplete data is a risk assessment. This approach "is firmly based in scientific considerations... is a process of weighing alternatives and selecting the most appropriate actions" (National Research Council 1983). The risk assessment process provides worst case analyses (maximum and accident scenarios) of reasonably foreseeable scenarios in which extreme exposure to herbicide occurs.

Throughout the analysis, data from tests on similar animals are used to estimate missing or incomplete information. Best conservative estimates were used. For example, a dermal penetration rate of 10 percent was assumed although it exceeds the most rapid rate of skin penetration reported.

#### a. Direct Effects

##### Acute Toxicity

All herbicides evaluated are rated slightly toxic or very slightly toxic to rats when eaten (acute oral toxicity) except for the amine formulation of 2,4-D, which was rated moderately toxic (appendix A, table 6-1).

Studies of acute oral toxicity in birds (generally mallards (Anas platyrhynchos) or bobwhite quail) showed all to be slightly or very slightly toxic except for 2,4-D (ester and amine) which was moderately toxic. No avian studies were available for 2,4-DP or limonene.

Diesel oil has been demonstrated to be lethal to chicken embryos at a very low concentration in a single dose (Weeks and others 1988a). At rates significantly higher than normal field application rates, reduced egg viability was demonstrated for dicamba, fosamine, picloram, 2,4-D (amine and ester) and 2,4-DP. This latter information is of concern in the accident scenario. No information was found for hexazinone, imazapyr, sulfometuron methyl, tebuthiuron, or triclopyr.



Using a scale proposed by Larry Atkins (University of California) all of the herbicides were rated relatively nontoxic (the least toxic category) to honeybees (Apis melliferu) except for dicamba (moderately toxic). The adjuvants limonene and diesel oil, however, were found to be highly toxic to honeybees. No information is available concerning the toxicity of kerosene to honeybees (appendix A).

The acute toxicity to fish of a given concentration of a chemical in water is rated on a scale of very highly toxic, highly toxic, moderately toxic, slightly toxic and practically nontoxic. Fosamine, glyphosate (Rodeo), imazapyr, tebuthiuron, triclopyr amine, and 2,4-D amine are classed as practically nontoxic; dicamba and sulfometuron methyl are classified as slightly toxic. Limonene is classed as moderately toxic and, depending on which fish species is tested, glyphosate (Roundup), picloram, and 2,4-DP are rated moderately or slightly toxic. Triclopyr ester is rated highly toxic to fish while, depending on the test fish, 2,4-D ester and diesel oil are rated highly or moderately toxic, and kerosene is rated anywhere from highly to slightly toxic (appendix A, tables 6-8 through 6-19).

Toxicity to aquatic invertebrates is reported (appendix A, tables 6-8 through 6-19) as follows:

- Practically nontoxic: fosamine, glyphosate (Rodeo), imazapyr, tebuthiuron, and triclopyr.
- Slightly toxic: hexazinone, picloram, and sulfometuron methyl.
- Moderately to slightly toxic: dicamba and glyphosate (Roundup).
- Moderately to practically nontoxic: 2,4-D amine.
- Highly to moderately toxic: 2,4-D ester, diesel oil, and kerosene.
- No information: 2,4-DP and limonene.

Toxicity data for amphibians is limited. 2,4-D amine and dicamba are classed by EPA as practically nontoxic; and picloram as slightly to practically nontoxic. No rating is available for the other chemicals.

## Irritation

In addition to knowing the potential of a chemical to cause death, it is also necessary to know if it is an irritant to skin or eyes. The risk assessment presents data concerning the amount of each chemical which causes primary dermal or eye irritation.

Registration standards required under the Federal Insecticide, Fungicide, and Rodenticide Act were developed for the protection of humans and their environment. For humans a set of four classes has been developed to describe the effects on dermal and eye irritation. This same level of precision is not required for animals. Data presented in this section are for mammals; rats and rabbits are the chief test animals used to determine primary skin and eye effects, and are virtually the only ones tested so far.

Dermal: Dermal irritation was reported (appendix A) as follows:

- None: hexazinone, tebuthiuron, and 2,4-DP.
- None to slight: glyphosate, imazapyr, and sulfometuron methyl.
- Slight (or mild): dicamba, picloram, triclopyr ester, kerosene, and limonene.
- None to moderate: fosamine.
- Slight to moderate: triclopyr amine, and 2,4-D (amine and ester).
- Extreme: diesel oil.

Dermal exposure to diesel oil at a relatively high rate for three weeks caused death of the test animals. Dermal exposure to kerosene for 28 days at a rate significantly higher than expected in the field resulted in severe skin and liver lesions in rats. At one-half the rate that caused these undesirable effects, (a rate which is still significantly higher than expected in the field), no negative effects were observed (Weeks and others 1988a) due to kerosene dermal exposure.

Eye: Eye irritation was reported (appendix A) as follows:

- None: fosamine (Krenite), diesel oil, and triclopyr ester.
- None to slight: glyphosate, imazapyr, and sulfometuron methyl.
- Slight (mild): picloram, tebuthiuron, 2,4-DP, kerosene, and limonene.
- Slight to moderate: dicamba and 2,4-D (amine and ester).

- Moderate to severe: fosamine (Krenite S) and triclopyr amine.
- "Irritating": hexazinone.

No Observed  
Effect Levels

The establishment of NOELs has been done primarily to develop human health guidelines. Animal testing is reported in the section on human health. Data do not exist for groups of animals other than mammals.

Effects of  
Inert Ingredients

A full discussion of the effects of inert ingredients is presented in the human health risk assessment summary. Kerosene is the only inert ingredient of toxicological concern in herbicides used in the Southern Region.

Acute Effects

The Environmental Protection Agency has published a standard for ecological risk assessment (EPA 1986a). Standards from this publication are used in subsequent discussion.

Terrestrial: The EPA standard for evaluating risk from herbicides and other chemicals to terrestrial wildlife is the comparison of actual dosage with the LD<sub>50</sub> (the amount of chemical which kills [Lethal Dose] one-half [50 percent] of the test animal population in an acute toxicity test). If the probable dose is less than one-fifth the LD<sub>50</sub>, it is considered to pose an acceptable level of risk for terrestrial wildlife. Any dose greater than one-fifth of the LD<sub>50</sub> is considered to pose unacceptable risk for terrestrial animals (EPA 1986a).

The wildlife risk assessment presents the full evaluation of wildlife risk from herbicides applied at normal and extreme rates. Comparison of LD<sub>50</sub> values with projected dose is presented in tables 8-4 through 8-14 of appendix A. A broad spectrum of animals is evaluated in the analysis; birds (common flicker, bobwhite quail, eastern bluebird, belted kingfisher, American kestrel, and red-cockaded woodpecker), mammals (southern short tailed shrew, red bat, eastern vole, grey squirrel, meadow vole, eastern cottontail, white tailed deer, cotton rat, eastern red fox, black bear, river otter, and bobcat), amphibian (woodhouse toad), reptiles (eastern box turtle, hognose snake, and gopher tortoise), and domestic animals (cow, chicken, and dog). Scientific names are in table 8-35 of appendix A.

Typical  
Scenario

Results presented in tables 8-4 through 8-14 of appendix A show that all 11 of the herbicides and 3 additives applied at typical rates pose less risk than allowed under the EPA standard for wildlife and aquatic animals not listed as threatened or endangered.



Maximum  
Scenario

Results of modeling maximum rates are mixed. Dicamba, diesel oil, fosamine, glyphosate, imazapyr, kerosene, picloram, and sulfometuron methyl pose less risk than allowed by the EPA standard for all animals evaluated. Limonene also posed a lower risk than allowed, but data are unavailable to evaluate its effects on birds, reptiles, and amphibians. Dosage to several mammals is greater than allowable for hexazinone, tebuthiuron, and triclopyr; 2,4-DP showed greater than acceptable exposure for several birds and mammals; and 2,4-D showed unacceptable doses for some species in each of the terrestrial animal groups.

In summary, risk is at a low ("no risk") level, according to EPA standards for terrestrial animals, for all wildlife when typical application rates of herbicides are used. Exceeding typical rates, times, or any other consideration which increases dose can cause a slight to severe level of risk. Several of the herbicides evaluated had low ("no risk") levels of risk at the maximum rate of application, however, several did not.

Aquatic: To evaluate the risk from herbicides in the aquatic environment, herbicide concentration is compared with the LC<sub>50</sub> (the concentration of any substance in water which will kill 1/2 of the test population; that is the Lethal Concentration for 50 percent of the test organisms.) The standard applied is: concentrations of less than one-tenth of the LC<sub>50</sub> pose no acute health risk; concentrations between one-tenth and one-half the LC<sub>50</sub> are presumed to pose a slight risk which can be mitigated; concentrations greater than one-half the LC<sub>50</sub> pose presumptive significant risk to aquatic species of acute effects which can not be mitigated (EPA 1986a).

The results of the risk assessment indicate that there is no significant risk of acute adverse effects to any of the representative aquatic species from drift either in a typical or maximum exposure situation.

Accident: Table IV-9 presents a summary of the risk resulting from a land accident in which 5 gallons of chemical are accidentally spilled into a pond (appendix A, tables 8-17 through 8-33. A spill of 2,4-D ester and triclopyr ester, 2,4-DP, diesel oil, glyphosate (Roundup), kerosene, and limonene pose significant risk to aquatic organisms. A spill of sulfometuron methyl poses a slight risk to almost all aquatic organisms. A spill of 2,4-D amine poses a slight risk to water fleas (Daphnia sp.) but none for other aquatic organisms. Dicamba, fosamine, glyphosate (Rodeo), hexazinone, imazapyr, picloram, tebuthiuron and triclopyr amine pose no risk to aquatic organisms from spills.

Table IV-9.—Risk of exposure of fish and aquatic animals from an accidental terrestrial spill of herbicide or adjuvant. Terrestrial spill is assumed to be an amount equal to that carried in a single container in a pickup truck (5 gal (19 l)). All chemical is assumed to reach the water (a pond). [NR] = No risk (according to the EPA standard) dose is less than 1/10 LC<sub>50</sub>; SL = Slight risk (can be mitigated), dose between 1/10 and 1/2 LC<sub>50</sub>; ■ = Severe risk, dose is larger than 1/2 LC<sub>50</sub>; — = No information available.

	2,4-D		2,4-D		GLYPHO				GLYPHO				PICLOR			
	AMINE	ESTER	2,4-DP	DICAMB	DIESEL	FOFAMI	RODEO	ROUNDU	HEXAZI	IMAZAP	KEROSE	LITONE	+2,4-D	SULFOM		
Rainbow trout	NR	■	■	NR	■	NR	NR	■	NR	NR	■	■	NR	SL		
Brook trout	NR	■	■	NR	■	NR	NR	■	NR	NR	■	■	NR	SL		
Largemouth bass	NR	■	■	NR	■	NR	NR	■	NR	NR	■	■	NR	SL		
Smallmouth bass	NR	■	■	NR	■	NR	NR	■	NR	NR	■	■	NR	SL		
Bluegill	NR	■	■	NR	■	NR	NR	■	NR	NR	■	■	NR	SL		
Green sunfish	NR	■	■	NR	■	NR	NR	■	NR	NR	■	■	NR	SL		
Fathead minnow	NR	■	■	NR	■	NR	NR	■	NR	NR	■	■	NR	SL		
Gizzard shad	NR	■	■	NR	■	NR	NR	■	NR	NR	■	■	NR	SL		
Northern hogsucker	NR	■	■	NR	■	NR	NR	■	NR	NR	■	■	NR	SL		
Mosquitofish	NR	■	■	NR	■	NR	NR	■	NR	NR	■	■	NR	SL		
Chain pickerel	NR	■	■	NR	■	NR	NR	■	NR	NR	■	■	NR	SL		
Crayfish	NR	NR	NR	—	SL	NR	—	NR	NR	—	NR	—	—	NR		
water flea	SL	SL	SL	NR	—	NR	NR	SL	NR	NR	—	—	NR	SL		
Stonefly nymph	—	■	■	—	—	—	—	SL	—	—	—	—	NR	—		
Virginia oyster	—	SL	SL	—	—	—	—	—	NR	—	—	—	NR	—		
Mudpuppy	NR	—	—	NR	—	—	—	—	—	—	—	—	NR	—		

	TRICLO		TRICLO	
	TEBUTH	AMINE	ESTER	
Rainbow trout	NR	NR	NR	
Brook trout	NR	NR	NR	
Largemouth bass	NR	NR	NR	
Smallmouth bass	NR	NR	NR	
Bluegill	NR	NR	NR	
Green sunfish	NR	NR	NR	
Fathead minnow	NR	NR	NR	
Gizzard shad	NR	NR	NR	
Northern hogsucker	NR	NR	NR	
Mosquitofish	NR	NR	NR	
Chain pickerel	NR	NR	NR	
Crayfish	NR	NR	—	
Water flea	NR	NR	—	
Stonefly nymph	—	—	—	
Virginia oyster	NR	NR	—	
Mudpuppy	—	—	—	



Table IV-10 shows the expected risk from an emergency aerial dump of 100 gallons of chemical into a reservoir (appendix A, tables 8-17 through 8-33). Only kerosene poses significant risk to aquatic organisms. 2,4-D ester, 2,4-DP, diesel oil, glyphosate (Roundup), and triclopyr ester pose slight risks to aquatic organisms, while 2,4-D amine, fosamine, glyphosate (Rodeo), hexazinone, imazapyr, limonene, picloram, sulfometuron methyl, tebuthiuron, and triclopyr amine are considered to pose no risk to aquatic animals.

Chronic and  
Cumulative Effects

Long-term studies have been performed on mammals to develop information for human health analyses (appendix A). These studies are given in the human health section. Studies evaluating the oncogenic or mutagenic potential of these chemicals on other animals (birds, reptiles, or amphibians) are not currently available. Chronic effects are highly improbable since it is unlikely that terrestrial animals would be exposed more than once in a lifetime from Forest Service activities. Where Forest Service lands border treated private lands, exposure could be more frequent, but still are unlikely to approach levels which could cause chronic health effects in wildlife.

Very limited information is available on chronic toxicity in aquatic animals for most chemicals (appendix A). There are no chronic toxicity data for dicamba, fosamine, glyphosate (either glyphosate formulation), imazapyr, or limonene. There are only single species data for 2,4-D ester, sulfometuron methyl, and the ester and amine formulations of triclopyr. Reasonably good data exist only for 2,4-D amine.

Risks of chronic effects, such as reproductive success or long-term survival, were estimated for aquatic organisms for those herbicides and species where sufficient data were available (appendix A). In no case was significant risk of adverse effect identified.

Cumulative poisoning of animals from a herbicide will result only if that substance bioaccumulates in the body. Tebuthiuron shows a slight tendency to accumulate in fish, but none of the other herbicides for which data are available show any tendency to accumulate (table 3-4, appendix A). Consequently, risk from cumulative exposure is not expected to exceed other risks discussed in the risk assessment. Furthermore, herbicide mixtures used in the Coastal Plain/Piedmont have not shown synergistic effects.

b. Effects on  
Habitat

Herbicides have an indirect effect on wildlife by altering vegetation species composition and structure. Depending on the herbicide applied, application rate and method, and vegetation affected, treatments can be detrimental to some wildlife species and beneficial to others. Herbicide





effects on wildlife can include an increase in snag availability, or a reduction or increase in hard-mast production, soft mast production, ground vegetation (forbs, grasses), and foliage height diversity (layers of vegetation present within a stand).

Habitat Alteration  
From Site  
Preparation

To prepare a site for regeneration, herbicides may be applied alone or in combination with prescribed fire or mechanical treatment. Site preparation may be accomplished by broadcast application or by treating individual stems by injection, thinline, or foliar spray application of herbicides. Sites prepared by herbicide without mechanical treatment support a greater diversity and abundance of bird populations (Darden 1980) because of downed and standing woody material.

When herbicides are applied in bands rather than broadcast over an entire area, deer forage production is slightly higher the first year (Blake, Hurst, and Thomas 1987). Site preparation by herbicides alone results in numerous snags which provide perching sites for raptors (hawks and owls) and potential nest sites and foraging habitat for cavity-nesting and insect-feeding birds. This habitat results in an overall increase of bird diversity in treated clearcuts (Dickson, Connor, and Williamson 1983; Warren, Hurst, and Darden 1984). Removal of shading vegetation may adversely affect reptile and amphibian species, but fallen snags eventually create cover for amphibians and sunning sites for reptiles.

Herbicides used with fire usually result in a stand with sparse ground cover at first. Mourning doves and small mammals such as cotton rats (Sigmodon hispidus) find early successional stages attractive (McComb and Hurst 1987; Perkins 1973). Production of preferred deer forage can increase for several years following initial reduction after treatment with herbicides such as 2,4-D (Hurst and Warren 1981). Herbicides such as glyphosate reduce grass and herbaceous species the year following treatment but production recovers during the second growing season (Copeland and Hurst 1986).

DeFazio Stone, and Warren (1988) found that site preparation by broadcasting tebuthiuron pellets followed by burning caused some reduction in woody deer browse but also caused increases in grass, sedge, and forb forage. Their results varied among areas studied and did not indicate that overall impacts on deer were significant but led them to conclude that "... an application rate greater than or equal to 3.1 kg a.i./ha may be inappropriate..."



## Habitat Alteration From Pine Release

Treatment of pine stands at 3-6 years of age to control hardwood stems tends to encourage growth of grass, forbs, and vines. This improves conditions for ground-feeding birds, white-tailed deer, and wild turkey by increasing seeds and forage (Hurst and Warren 1986). When applied by broadcast methods, however, these treatments reduce the number of soft-mast producers such as vacciniums and dogwood, which are used by many species of wildlife. Herbicide applications which result in top-kill of hardwoods tend to reduce mast production by relegating many mast-producers to the midstory of the future stand. Root-kill applications cause a more serious reduction by eliminating certain mast-producers altogether. This can have a detrimental effect on deer, turkey, gray squirrels, and many species of songbirds.



Release by selective methods such as spot-around or foliar spray makes it possible to leave individual stems or clumps of mast-producing or other desirable hardwoods. Studies of stands treated with 2,4-D show that retaining even small scattered patches of brush helps maintain bird density and abundance after treatment (Morrison and Meslow 1984b).

The use of herbicides such as glyphosate, which control grasses and herbaceous vegetation, results in temporary reduction in forage. But species composition, total biomass, and forage production are usually similar to untreated areas by the second growing season (McComb and Hurst 1987).

Accelerated growth of pine which results from successful release treatment may benefit some wildlife species because it allows pine stands to be burned and thinned sooner (Owen 1984). Broadcast application of imazapyr increases



production of forbs and vines, including important deer forage species like blackberry and dewberry, while reducing woody browse (Hurst 1987).

Habitat Alteration  
From Stand  
Improvement

When used for timber stand improvement (TSI), injection of competing hardwood stems in mixed pine-hardwood stands reduces hard-and soft-mast production unless selected stems are left. This reduction harms species such as white-tailed deer, gray squirrel, and many songbirds. Increased snag availability, however, benefits cavity nesters and small mammals that will use openings created in the stand (McComb and Rumsey 1982). Snags created by herbicides tend to remain standing for a shorter time than those created by other means such as girdling (Conner, Kroll, and Kulhavey 1983). Shrub fruit-producers and vines such as honeysuckle increase, benefiting white-tailed deer and many birds. Increased pine seed production benefits fox squirrels and other species.

In the short run and possibly in the long run, bird abundance and diversity increase when some overstory in upland hardwood stands is removed by broadcasting picloram or 2,4-D. The increase is probably due to the resulting increase in the diversity of vegetation layers (McComb and Rumsey 1983; Morrison and Meslow 1984a, 1984b.) Habitat for foliage-gleaning birds, however, may be reduced.

Applied selectively for wildlife stand improvement (WSI), herbicides release mast-producing hardwoods and increase mast production for deer, turkey, squirrel, bear, and other species. When hardwood midstories are reduced, production of deer forage increases, especially when prescribed fire is also applied (Blair and Feduccia 1977).

Habitat Alteration  
From Rights-of-Way  
(ROW) and Openings  
Maintenance

Wildlife openings and rights-of-way corridors provide early successional stage habitat. Such habitats vary from grass/forb to brush cover depending upon how they are maintained. They also provide transitional zones or "edge," which may increase species diversity. When ROWs transect and fragment large intermediate or mature hardwood stands, some bird species which need large stands to reduce nest parasitism and predation may decline. Although little research exists, naturally created edges (as by wildfire) may reduce this effect compared to abrupt artificial edges (Reese and Ratti, in press).

Use of herbicides in wildlife openings maintenance is usually directed at control of persistent non-native grasses such as fescue or control of encroaching hardwood brush. This treatment helps establish native or other grasses, legumes, and forbs. Broadcast application of liquid hexazinone has been used successfully to create wildlife openings for turkey in the Ozark Mountains (Nelson, Hartman, and Leeds [1988]).

Herbicides on ROW corridors may be broadcast or selective. Repeated treatments may result in a low-shrub community which is stable and resistant to invasion by tree species. Such a community develops more rapidly and without the initial loss of brush cover when selective spraying is used (Eaton and Gates 1981). It usually has a substantial soft-mast producing component, and is more beneficial to some small mammals and deer than a grass-forb community (Ladino and Gates 1981). Arner (Mississippi State University, personal communication), however, found that this type of treatment in Mississippi tended to favor sumacs (Rhus spp.) rather than fruit-producers such as vacciniums which are more valuable to many species of wildlife. When shrub cover is patchy and varying in height, a greater diversity of bird species will occur (Kroodsma 1982).

Selective herbicide application to brush or trees that reach a predetermined height results in habitat favorable for white-tailed deer (Bramble, Byrnes, and Hutnik 1985) and some songbirds (Kroodsma 1982; Myers and Provost 1981).

Habitat Alteration  
From Range  
Treatment

Herbicides are used to alone or in conjunction with other treatments to reduce encroachment of brush on grasslands managed for grazing. Control of brush in small blocks or strips is generally beneficial to deer and turkey. Total control of brush harms many species of songbirds, small mammals, and raptors (Holechek 1981).

2. Effects of  
Prescribed Fire

a. Direct Effects

Because most animals in the Coastal Plain/Piedmont are adapted to periodic fires of natural and man-caused origin, direct mortality from prescribed fire has a negligible effect upon animal populations (Lyon and others 1978). Less mobile species such as shedding diamondback rattlesnakes (Crotalus adamanteus) (Means and Campbell 1981) or frogs (Vogl 1973) may occasionally be killed. Most observers, however, indicate that this is rare (Komarek 1969) and that mortality is not normally associated with slow-moving prescribed fires. Furthermore, even fires started by an aerial ignition pattern which results in numerous spot fires rather than linear flame fronts do not result in significant vertebrate mortality (Folk and Bales 1982). A notable exception is the Eastern glass lizard (Ophisaurus ventrali) which may be killed in considerable numbers when prescribed burns are conducted (Means and Campbell 1981).

Larger animals such as white-tailed deer usually move calmly away from advancing fires. There is no evidence that wildlife is harmed by smoke. Raptors, bobwhite quail, turkey, and insectivorous birds are often attracted to recently burned or actively burning and smoking areas (Komarek 1969; Landers 1987; Lyon and others 1978; Stoddard 1963). When burns are conducted during the nesting season, some eggs and young of ground-nesting species are

destroyed. Although it is possible for direct heating of small streams by fire to result in the mortality of aquatic organisms, mitigation measures do not allow prescribed fires to achieve the intensities or duration necessary for this to occur and any mortality would be restricted to short stretches of water.

b. Effects on  
Habitat

Because lightning-set and man-caused fires have occurred periodically in the Coastal Plain/Piedmont for several thousand years, animals have adapted to habitats subjected to recurring fires. Some, like bobwhite quail, depend upon fire to maintain their environment (Landers 1987).

Prescribed burning affects different species in different ways. Some effects on wildlife habitats include an increase in the amount, availability, and palatability of forage; changes in production of soft mast; changes in invertebrate populations; and the creation and destruction of snags (Van Lear and Johnson 1983).

Without periodic prescribed burning in most southern pine types, increased fuels increase the occurrence of intense and unplanned wildfires. Habitat alteration from these fires is often severe since overstory vegetation, as well as smaller woody stems, may be destroyed.

A major research need in the area of prescribed fire is the relationship of prescribed fire effects to fire behavior. In other words, how do intensity, duration, and season of burning affect various wildlife species? Data related to effects of burning on many species in the South, particularly songbirds, reptiles, and amphibians, are meager.

Habitat Alteration  
From Site  
Preparation

Prescribed fire is used alone or with herbicide or mechanical treatments. Depending upon intensity, broadcast burns may remove very little to virtually all live vegetation and residue. This condition is temporary, however, because roots, bulbs, and dormant seeds are stimulated by fire and soon sprout. Conditions soon become favorable to ground feeders like meadowlarks (Sturnella magna). Deer forage and production of seeds used by birds such as quail increase dramatically, peaking the first or second season after burning (Stransky and Halls 1979b; Warren 1981.) After 2 or 3 years, conditions improve for species such as cottontail rabbits and cotton rats. Fruits, important to species such as black bear, decrease initially but soon increase (Hamilton 1981).

Except for intense fires that destroy much of the ground cover and increase sedimentation risk on small streams, prescribed burns have little impact on Coastal Plain/Piedmont fish populations (Seehorn 1987).



Habitat Alteration  
From Stand  
Improvement

Prescribed underburns are carried out in pine and pine-hardwood stands ranging from saplings to mature stands. Whether they are used to improve conditions for wildlife or range, reduce hazardous fuels, or control competing vegetation, their effects on wildlife are similar. Effects vary, however, according to season, intensity, and frequency of burns.

Burning has long been used as a tool in the Coastal Plain/Piedmont to improve white-tailed deer habitat. Research indicates that nutrient content (particularly protein and phosphorous) and palatability of deer food increase temporarily after burning. But effects on deer browse from wildlife or fuel-reduction burns applied at 3-5 year intervals may be small and short-lived (Wood 1988). Also, fruit yields of understory shrubs decrease immediately, then increase to levels higher than before burning and decline gradually. Optimum fruit production probably occurs when pine stands are burned every three years (Johnson and Landers 1978). In addition, deer browse decreases initially, but increases rapidly for several years afterward (Blair and Enghart 1976; Hurst and Warren 1982; Stransky and Harlow 1981). Browse after burning generally grows out of the reach of deer after 4-5 years (Landers 1987). Repeated burns, particularly during the growing season, may reduce the amount of woody vines such as honeysuckle, an important deer food (Landers 1987). Consequently, protecting some areas from burning is important.

Periodic dormant-season burning of scattered areas probably benefits black bear because it increases production of some fruits and succulent saw palmetto shoots (Hamilton 1981). Prescribed burning benefits most fur-bearers because fire increases prey abundance and availability. Burns also increase production of fruits such as blackberry and blueberry. Production of important foods such as persimmon and grapes, however, may decline (Johnson and Landers 1978; Miller and Speake 1978).

Many small mammals need the early successional forest stages created or maintained by fire. Long-term studies indicate that rodents such as the eastern harvest mouse (Reithrodontomys humulis) and hispid cotton rat, which feed on seeds and grass, usually increase after prescribed fire. Insectivorous mammals like short-tailed shrews tend to decrease (Landers 1987). Other (short-term) studies have shown immediate reductions of mice and rats accompanied by increases of shrews (Landers 1987; Fala 1975). When fire is used to control hardwoods in pine stands, it generally has a negative impact on squirrels since it reduces future production of acorns. This is particularly true where fire

is used to maintain a wiregrass community (Landers 1987). Fire may be beneficial to gray squirrels, however, when it is used to maintain low-growing oak species or promote a lush groundcover which provides escape cover (Hillard 1979). Habitat will generally remain suitable for squirrels as long as scattered patches of mast-producing hardwoods remain interspersed in pine stands (Landers 1987). Prescribed fire, particularly patchy burning done annually or biennially, appears to be beneficial to rabbits (Hill 1981).

Annual or biennial dormant-season burning for quail is a common management tool in the Coastal Plain/Piedmont. Most managers agree that fire should be excluded from some areas to provide 2-3 year old roughs necessary for nesting cover and soft-mast production (Hurst 1981; Landers 1981; McRae and others 1979). Burning for management of wild turkey is also common, although it is generally conducted on a longer (3-5 year) rotation than burns for quail management. Benefits include increases in legumes, reduction in external parasites, maintenance of brood habitat for poults, and increases in the arthropod food supply. Early growing season burns or burning less frequently than every 5 years may reduce lespedezas and other legumes important as food sources for quail and turkey (Lewis and Harshbarger 1976, 1986; Speake 1966). Decline in hard-mast, important for turkey, squirrels, and many other species, may result from repeated burning.

Burning has effects on other bird species as well. Prescribed fires may eliminate standing dead trees that provide cavity nest sites. However, fires also kill trees, thus providing sites for new cavities (Conner 1981). According to Dickson (1981), burning increases early successional species such as Bachman's sparrow (Aimophila aestivalis) and birds such as pine warblers (Dendroica pinus) which inhabit intermediate to mature pine stands. When variations in fire behavior result in patchy vegetation, bird diversity tends to increase (Landers 1987).

Periodic burning helps to temporarily provide open conditions. Such conditions make hunting of small mammals and birds by hawks easier, and tend to attract many species of predatory birds. Red-tailed hawks (Buteo jamaicensis), kestrels (Falco sparverius), and loggerhead shrikes (Lanius ludovicianus) often feed in freshly burned areas (Komarek 1969).

Little research exists on fire effects on reptiles and amphibians in the South. It is apparent, however, that frequent burning of the sandhills community apparently helps maintain a high diversity of "sand-swimming" reptiles which inhabit loose sand (Mushinsky 1985). Bog species like the

pine barrens treefrog (Hyla andersoni) benefit when prescribed fire is used to control encroachment of woody species (Means and Moler 1979).

Most prescribed underburns are conducted during the dormant season. But the need for growing-season burns to perpetuate the longleaf pine/wiregrass community and its associated wildlife species in Florida has recently been debated. Season of burning is important since early growing-season burns apparently favor grasses and forbs while late growing-season burns favor low, fruit-producing shrubs, runner oak acorns, and perennial legumes. Dormant-season burns favor annual legumes and woody vegetation. Burning during the early growing season probably resembles the natural regime of lightning-ignited fires under which animals inhabiting this type evolved. Exclusion of fire from this ecosystem gradually degrades the habitat which supports a unique association of plants and animals.

Growing-season burning may be most beneficial for many wildlife species when it is alternated with dormant-season burns (personal communication, Bill Platt, Tall Timbers Research Station).

Habitat Alteration  
From ROW and  
Openings  
Maintenance

Prescribed fire is not commonly used in the Coastal Plain/Piedmont as a means of managing vegetation in openings and ROWs. Limited research indicates that compared to mechanical or herbicide treatments, dormant-season burning produces more arthropods and insects for birds to feed on (Hurst 1970) and may produce more legumes and other plants used by birds like quail (Huntley and Arner 1981).

Habitat Alteration  
From Range  
Treatments

Prescribed burning for range produces responses similar to those of stand improvement burns. In addition to improving forage quantity and quality for cattle, range burns improve browse conditions for deer. In longleaf pine-bluestem range, burning also lessens competition between cattle and deer by reducing the amount of diet overlap between the species (Thill 1982).

**3. Effects of  
Mechanical Methods**

a. Direct  
Effects

Mechanical methods occasionally cause direct mortality of adult animals or result in destruction of eggs or young. Normally, vertebrate species are able to flee in advance of equipment and escape harm, although some reptiles and amphibians may be killed. Mowing, chopping, shearing, raking, disking, and other mechanical tools cause some direct mortality to invertebrates, but, because of large populations and high reproductive rates, populations are not hurt. Destruction of eggs and young depends upon season of treatment and can occur when equipment is used during the nesting season.



Disturbance caused by equipment used for site preparation may result in abandonment of young or nests. With larger vertebrates such as deer or rabbits, such abandonment is normally temporary. Ground-nesting birds may permanently abandon nests if disturbance occurs soon after nesting begins but will tolerate greater disturbance when eggs are close to hatching. Although most ground-nesters will renest, survival rates for young from late-season nesting attempts are generally lower.

b. Effects On  
Habitat

Specific research on the effects of mechanical treatments on many species is scarce. Fortunately, since data regarding the effects of mechanical treatments on vegetation structure and species composition are available, conclusions regarding effects on wildlife can be made. In some ways, effects are similar to those resulting from herbicide or fire, but vary depending on the degree to which root stocks are destroyed.

Habitat Alteration  
From Site  
Preparation

As with prescribed burning, most mechanical site preparation treatments increase the number of plant species and amount of herbaceous ground cover as compared with uncut, mature forest stands. More intensive mechanical methods, however, such as raking reduce the number of woody fruit-producers (Swindel, Conde, and Smith 1984; Stransky and Halls 1980; Stransky and Roesse 1984).

Small seed-eating mammals that use early successional habitat benefit more from mechanical site preparation if windrows, scattered brush cover, and downed logs are not removed (as by burning) (Buckner and others 1979). Rabbits and many reptiles and amphibians benefit as well. Short-term (up to age 5) increases in deer forage following mechanical treatments can be dramatic. Chopping, which does not destroy plant root systems, generally results in higher browse production than more intensive methods (Stransky and Halls 1979b). Sites prepared by bedding seem to attract fewer rabbits than do sheared or chopped sites (McKee 1973).

When intensive mechanical treatments such as shear, rake, and windrow are used in conjunction with burning, soft-mast species such as blackberry and pokeweed soon invade (Campo and Hurst 1980). These open sites attract ground feeders such as mourning doves the first year following treatment. As more cover becomes available (2-3 years), species such as bobwhite quail utilize the site. Turkey use the areas for nesting cover as well. Retaining windrows also increases use by species such as house wrens (Troglodytes aedon) (Rowse and Marion 1981). With all site preparation methods, retention of snags greatly increases use by cavity nesters and raptors.

Based on limited research, it appears that intensive treatments which remove debris reduce the numbers of reptiles and amphibians. However, intensive treatments may provide habitat for tree-dwelling reptiles sooner than less-intensive treatments. A patchy distribution of habitats allows for more rapid recolonization after treatment (Enge and Marion 1985).

Fish and other aquatic organisms are harmed when erosion caused by soil disturbance results in stream siltation. Where streamside buffer strips and proper techniques (such as using a sharp dozer blade and not allowing the blade to penetrate below the ground) are used, siltation is insignificant (Seehorn 1987). Streamside zones also provide shade which is necessary for maintaining water temperatures required by aquatic organisms.

When deposited in streams, excessive slash created by site preparation harms fish populations by reducing dissolved oxygen and trapping sediment. Small amounts of slash, however, when properly placed, enhance fish habitat (Seehorn 1987).

#### Habitat Alteration From Other Stand Treatments

Use of mechanical treatments for other purposes is minor. Effects are similar to those discussed in the preceding section. Chopping for pine release helps species such as deer by opening strips in dense stands, thus increasing production of forbs and legumes.



#### Habitat Alteration From ROW and Openings Maintenance

Mowing is the primary mechanical method for maintaining ROWs and wildlife openings. Mowing maintains a grassy groundcover which can provide nesting and bugging habitat for turkey, and cover for several species of rodents. Frequent mowing, however, reduces cover for species like cotton rats

and ground-nesting birds (Schmidly and Wilkins 1977). Less-frequent mowing and strip mowing benefits most wildlife species found in ROWs because such practices leave islands of cover for nesting and escape.

Light disking is sometimes used to break-up grass cover and encourage native legumes, which are an important food for ground-feeders like quail.

#### **4. Effects of Manual Methods**

It is unlikely that manual methods cause any direct mortality except when removal of brush or trees destroys nests or young. Human disturbance may cause temporary or permanent abandonment of young or nests. Losses are minor and can be reduced if workers resist the temptation to "rescue" apparently orphaned animals. Normally, disturbance is short-lived, as workers move on to untreated areas and animals return. Effects on habitat are similar to those described for mechanical techniques which do not disturb the soil.

#### **5. Effects of Biological Methods**

Insignificant direct mortality occurs when livestock trample nests or the young of ground-nesting birds. Also, there is a potential for transmission of diseases such as epizootic hemorrhagic disease (which affects deer) from livestock to wildlife populations.

In the pine lands of the Coastal Plain/Piedmont, heavy year-round grazing reduces quality of habitat for many wildlife species. Research indicates, however, that light to moderate cattle grazing generally has little adverse impact on seed-producing plants important to ground feeders (Lewis and Harshbarger 1986). Short periods of intense grazing tend to reduce grasses and increase forbs eaten by deer and turkey (Moore and Terry 1979) and tend to improve bobwhite quail habitat (Schulz and Guthery 1988).

#### **E. THREATENED, ENDANGERED, PROPOSED, AND SENSITIVE SPECIES**

##### **Introduction**

The generalizations regarding effects of vegetation management on wildlife presented in section D also apply to species listed as threatened, endangered, proposed, and sensitive. Procedures outlined in chapter II, including the site-specific biological evaluation and environmental assessment processes, are designed to ensure that these species are protected when vegetation management projects (including those designed to benefit the species) take place. Forest inventories, Forest Land and Resource Management Plans, recovery plans, and Forest Service Handbook chapters are also important.



For some other species, particularly those adapted to a disturbance-related environment, use of vegetation management techniques such as prescribed burning to mimic natural disturbances is essential for continued species viability. The red-cockaded woodpecker, for example, requires open pine stands without a hardwood midstory. Prescribed fire on a 2-3 year rotation will maintain habitat that is already suitable. Herbicide, manual or mechanical treatments, or growing season burns are required to control hardwood stems larger than 2 inches and restore habitat suitability to colony sites with encroaching hardwoods (FSH 2609.23R R8 AMEND 13).

As discussed in chapter II, recovery plans and Forest Service Handbook chapters have been prepared for several threatened, endangered, and proposed species. With some of these species, factors such as poaching or loss of critical habitat outside of national forests combine to hinder species recovery. Recovery plans and handbook chapters consider these factors when establishing guidelines for Forest Service practices which may affect threatened, endangered, and proposed species.

There is a need for recovery plans and handbook chapters to be prepared for each of these species in the Southern Region and for each national forest to prepare guidelines for protecting and managing sensitive species occurring on the forests.

General effects of vegetation management methods on threatened, endangered, proposed, and sensitive species are presented in tables D-1 through D-6 in appendix D (the biological evaluation for this document). Measures to mitigate these effects are presented in appendix D and in chapter II.

## **1. Effects of Herbicides**

### **Terrestrial Species**

The EPA standard for chemical exposure considers a dose of less than 1/10 LD50 as not presenting a significant risk for a threatened or endangered terrestrial species. Based on toxicity data and exposure predictions made in the risk assesment, most of the herbicides analysed do not present a significant risk to any threatened, endangered, or proposed species when applied at typical rates. There is a probability of significant risk (dose exceeds 1/10 LD50), however, from 2,4-D and 2,4-DP to the Florida scrub jay, Indiana bat, and gray bat. Significant risk exists as well from exposure of the Indiana and gray bat to triclopyr. 2,4-D also presents a significant risk to the following sensitive species: star-nosed mole, Florida mouse, old-field mouse, masked shrew, southern shrew, southern pygmy shrew, and red-backed vole.

If applied at maximum rates, 2,4-D, 2,4-DP, dicamba, hexazinone, tebuthiuron, and triclopyr present a significant risk to most of the threatened, endangered, and proposed species listed in table III-5 and most of the sensitive species listed in III-7.

Low toxicities, low risk of exposure, and mitigation measures (detailed in chapter II) governing the use and handling of herbicides, combined with requirements for site-specific inventories and environmental analysis, make the probability of direct toxic effects on threatened, endangered, proposed, or sensitive animals low. Key mitigation measures include a restriction on application at greater than typical rates and limitations on use of herbicides identified in this chapter as posing significant risk.

#### Aquatic Species

The EPA standard for threatened, endangered, or proposed aquatic animals identifies an exposure of greater than 1/20 LC50 as presenting a significant risk. Based on predictions regarding exposure of the representative species analysed in the risk assessment to two accidental spill scenarios, the endangered shortnose sturgeon and Louisiana pearl mussel face a significant risk from a spill of 2,4-D ester, 2,4-DP, diesel oil, the Roundup formulation of glyphosate, kerosene, limonene, sulfometuron, and the ester formulation of triclopyr.

An accidental spill of these chemicals poses a significant risk to the following sensitive aquatic animals as well: Suwannee bass, flame chub, crystal darter, freckled darter, bluenose shiner, Lake Eustis shiner, Sabine shiner, gulf sturgeon.

Mitigating measures in chapter II regarding the transportation, handling, and application of herbicides are designed to make the likelihood of such an accidental spill very small.

#### Plant Species

Threatened, endangered, proposed, and sensitive plant species can be extremely sensitive to the effects of herbicides and direct treatment can destroy a local population. If the population is isolated, as many are, there may be no means for natural reestablishment. Response varies depending on several factors. Dicamba, for instance, might kill Florida gooseberry, a woody plant, but have little effect on a herbaceous species like Ocala vetch. Stem injection of hardwoods with picloram would not threaten a nearby population of Oglethorpe oak, whereas foliar spraying might. Although risk is lower when a herbicide has low efficacy for controlling a particular plant species, all of the herbicides analyzed are toxic to any plant when applied at sufficient rates, and are considered to pose a

significant risk to all threatened, endangered, proposed, and sensitive plants occurring in the Coastal Plain/Piedmont. This risk may be mitigated by conducting site-specific inventories and environmental analysis and by carefully selecting chemical, rate, method and season of application (see chapter II).

Sensitive plants may benefit, however, when herbicides are used to control competing vegetation, providing that non-target species are not inadvertently damaged by the application.

## **2. Effects of Prescribed Fire**

Some plant species are stimulated by fire. Others, such as the Florida gooseberry, are harmed and should be protected. Several species are associated with habitats that are created or maintained by fire. For example, without periodic burning, habitat for the red-cockaded woodpecker, becomes unsuitable. Past exclusion of fire from these species' habitat has hastened their decline. Season and intensity of burning, however, must be controlled to prevent habitat damage.

## **3. Effects of Mechanical Methods**

Most threatened, endangered, or proposed plant species are harmed by mechanical treatments, particularly those techniques that disturb the soil. Some plants may benefit by release from competing vegetation or be stimulated to reproduce.

As with burning, mechanical treatments may either harm or benefit these species. Gopher tortoises, for example, may benefit from treatments such as chopping (combined with herbicide application or burning). These treatments allow a rapid reinvasion by groundcover plants used by the tortoise. But the animal may be harmed by soil-disturbing treatments like heavy disking.

## **4. Effects of Manual Methods**

Manual treatments are less likely than mechanical treatments to be harmful to threatened, endangered, proposed, or sensitive plants since they do not disturb soil or root systems. Most woody species will respond by resprouting, but others may be killed if treated directly.

## **5. Effects of Biological Methods**

Some plants may respond favorably to light grazing. Others, such as Biltmore sedge, should be protected from foraging animals.

As with other species, heavy, continuous grazing damages habitat. Short-duration grazing, however, may benefit some species like gopher tortoise by causing vegetation response similar to that caused by wild herbivores (American bison) which formerly occupied their range.



## F. SOIL

### Introduction

Productivity, a site's ability to grow vegetation over time, depends on physical, chemical, and biological qualities of the soil. Productive soils have loose and porous structure, ample reserves of organic matter and nutrients, and balanced populations of small organisms.

Sensitivity to disturbance varies with soil fertility. Poor soils (entisols, severely eroded soils) are infertile (low in organic matter and nutrients) and highly sensitive. Fair soils (inceptisols, spodosols, and partly eroded soils) are intermediate in fertility and moderately sensitive. Good soils are fertile and slightly sensitive (table IV-11).

Table IV-11.--Distribution of soil fertility classes in the various landtypes\*

<u>Landtype</u>	-----Percent of Landtype-----		
	<u>Poor</u>	<u>Fair</u>	<u>Good</u>
COASTAL PLAIN			
Oak Savannahs	--	--	100
Upper Hills	15	30	55
Rolling Uplands	--	--	100
Clay Flatlands	--	--	100
Loess Uplands	20	50	30
Mississippi Valley	--	--	100
Gulf Flatwoods	15	35	50
Atlantic Flatwoods	5	15	80
Sand Ridges	60	10	30
PIEDMONT	30	50	20

\*See Figure IV-3, section G (Water) for map of landtypes

### 1. Effects of Prescribed Fire

Prescribed fire has both favorable and adverse effects on soil. Favorable effects are temporarily enhanced nutrient availability and phosphorus cycling and reduced soil acidity. Adverse effects are caused by soil heating, soil erosion, and nutrient leaching. Soil heating can kill soil biota, alter soil structure, consume organic matter, and remove site nutrients during the burn. Soil erosion and nutrient leaching occur during later rainstorms and cause smaller nutrient losses (appendix B).

There are three types of prescribed fire: (1) slash burns in harvested stands; (2) underburns beneath stands; and (3) grassland burns. Effects on soil vary with type of burn.

Slash burns occur once every 40-80 years for site preparation. Risk of adverse effects depends mostly on fire severity. It differs from fire intensity. An intense slash burn done when duff, soil, and larger fuels are moist will seldom be severe (Van Lear and Danielovich 1988).

Underburns occur every 1-7 years and are usually light to moderate in severity. Adverse effects from a single burn are minimal. Risk of adverse effects from repeated burns depends mostly on their frequency and season of use.

Like underburns, grassland burns occur every 1-7 years and are light to moderate in severity. Risk of adverse effects depends mostly on frequency of burn.

#### Soil Heating

Light slash burns scorch the litter and duff on most of the area. Soil heating has little effect on soil biota, structure, or organic matter. Less than 150 lb/ac of nitrogen is released as gas from slash, litter, and duff. Effects on other soil nutrients (phosphorus, potassium, calcium, magnesium) are favorable (appendix B).

Moderate slash burns char and partly consume the litter and duff on most of the area. Soil biota are reduced but recover quickly. Soil structure is not affected. Much litter and duff may be consumed, but soil organic matter is little affected. Between 300 and 350 lb/ac of nitrogen may be released as gas from slash, litter and duff, and topsoil. Other soil nutrients are little affected (appendix B).

Severe slash burns consume all litter and duff and alter the color and structure of mineral soil on most of the area. Destruction of soil biota sterilizes the site and full recovery takes years. Soil porosity, infiltration, and moisture capacity are reduced. About 90 percent of litter and duff and 50 percent of topsoil organic matter are often consumed. Between 650 and 850 lb/ac of nitrogen may be released as gas from slash, litter and duff, and topsoil. Large amounts of phosphorus may also be lost (appendix B).

Underburns more frequent than every 3 years do not affect soil biota, but litter-duff biota are reduced and do not fully recover before the next burn. Loss of organic matter exceeds 10 percent. Nitrogen loss may be up to 160 lb/ac for dormant season burns and 600 lb/ac for growing season burns. Annual underburns also impair soil porosity and infiltration (appendix B).

Underburns every 3-4 years allow litter-duff biota to fully recover between burns. Soil physical properties are not affected. Loss of organic matter is about 5 percent. Nitrogen loss may be 100-150 lb/ac for dormant season burns and 400-450 lb/ac for growing season burns (appendix B).

Underburns every 5 years or more have little effect on biota and soil structure. Organic matter increases by about 5 percent. Nitrogen loss may average 90 lb/ac for dormant season burns and 240 lb/ac for growing season burns (appendix B).

In grasslands, most biomass and nutrients are below ground. Nutrient loss is less harmful than in forests. Annual burns, however, pose high risk to soil productivity via reduced litter biota, impaired soil porosity and infiltration, and reduced organic matter. Risk is minimal for cycles of 3 years or more (appendix B).

#### Soil Erosion

Effects of prescribed fire on soil erosion depend on fire severity. Severe slash burns can cause serious erosion, because they expose mineral soil on much of the area and recovery may take 3 years. Moderate burns cause minor erosion, because they expose soil on less than 20 percent of the area and recovery usually takes 1 year. Light burns cause no erosion because they expose almost no soil (Dissmeyer and Stump 1978). Underburns and grassland burns are usually light to moderate, so their effect on erosion is generally negligible (appendix B).

Potential erosion is estimated by the Universal Soil Loss Equation (USLE). USLE computes potential erosion to increase with greater rainfall energy, soil erodibility, and slope length and steepness; and to decrease with greater ground cover provided by vegetation, litter, rock, and fine roots (Dissmeyer and Foster 1984). Average values of rainfall, soil, and slope factors for the various landtypes (Dissmeyer and Stump 1978) are shown in table IV-12.

Effects of fire on ground cover were estimated from many field observations in the South (Dissmeyer and Stump 1978) as modified by erosion research (Blackburn, Wood, and DeHaven 1986; Brender and Cooper 1968; Cushwa, Hopkins, and McGinnes 1971; Douglass and Van Lear 1983; Goebel, Brender, and Cooper 1967; Miller 1984; Ursic 1969, 1970). USLE's cover factor is estimated at 0.000 for light burns, 0.002 for moderate burns, and 0.015 for severe burns. Potential erosion in the various landtypes (appendix B) is shown in table IV-13.

#### Nutrient Leaching

Leaching losses from prescribed fire depend on fire severity. Nitrogen is often mobilized in the topsoil after fire by infiltration and fixation. Some is leached through the soil and into streams. Losses of nitrogen may be 1 lb/ac for light burns, 3 lb/ac for moderate burns, and 20 lb/ac for severe burns. Losses of other, less mobile nutrients are negligible. Underburns do not cause significant leaching losses because nutrients are retained through uptake by unburned plants (appendix B).



Table IV-12.--Average values of USLE factors for the landtypes

<u>Landtype</u>	-----USLE Factors-----				
	<u>Slope Steepness (Percent)</u>	<u>Slope Length (Feet)</u>	<u>Rainfall</u>	<u>Soil Erodibility</u>	<u>Slope/ Length</u>
COASTAL PLAIN					
Oak Savannahs	5	200	275	0.24	0.76
Upper Hills	10	180	275	0.24	1.85
Rolling Uplands	5	100	425	0.24	0.54
Clay Flatlands	3	80	360	0.32	0.27
Loess Uplands	10	110	350	0.37	1.40
Mississippi Valley	1	100	350	0.37	0.13
Gulf Flatwoods	1	200	500	0.20	0.16
Atlantic Flatwoods	1	200	350	0.24	0.16
Sand Ridges	3	200	375	0.17	0.35
PIEDMONT	15	110	260	0.32	2.70

Table IV-13.--Potential erosion (tons per acre) for treatments by landtype

<u>Landtype</u>	<u>Mod. Burns Herbicides</u>	<u>Chop-Shear Pile</u>	<u>Severe Burns Rake-Bed</u>	<u>Heavy Disk</u>
COASTAL PLAIN				
Oak Savannahs	0.10	0.15	0.75	3.01
Upper Hills	0.24	0.37	1.83	7.33
Rolling Uplands	0.11	0.17	0.83	3.30
Clay Flatlands	0.06	0.09	0.47	1.87
Loess Uplands	0.36	0.54	2.72	10.88
Mississippi Valley	0.03	0.05	0.25	1.01
Gulf Flatwoods	0.03	0.05	0.24	0.96
Atlantic Flatwoods	0.03	0.04	0.20	0.81
Sand Ridges	0.04	0.07	0.33	1.34
PIEDMONT	0.45	0.67	3.37	13.48

## Long-term Effects

Nitrogen budgets (table IV-14) show that timber harvest followed by light slash burns produces positive nitrogen budgets and allows long-term nitrogen buildup. Moderate burns produce neutral nitrogen budgets. Severe burns produce negative nitrogen budgets and cause long-term nitrogen depletion; losses over one timber rotation amount to 21 percent of site total in poor soils, 16 percent in fair soils, and 14 percent in good soils (appendix B).

Table IV-14.--Cumulative nitrogen budgets (lb/ac) for pine stands on 60-year rotations

	<u>Light Burns</u>	<u>Moderate Burns</u>	<u>Severe Burns</u>	<u>Piling</u>	<u>Raking</u>
LOSSES					
Harvested Stems	140	140	140	140	140
Slash Removal	28	55	99	99	99
Litter Removal	100	200	360	200	360
Soil Heating*	-	60-105	220-385	-	-
Soil Displacement*	-	-	-	-	200-350
Soil Erosion#	-	1	11	2	11
Leaching	<u>61</u>	<u>63</u>	<u>80</u>	<u>63</u>	<u>70</u>
TOTAL	329	519-564	910-1075	504	880-1030
INPUTS					
Atmospheric	300	300	300	300	300
Plant Fixation	100	100	100	20	20
Other Fixation	<u>200</u>	<u>200</u>	<u>200</u>	<u>180</u>	<u>180</u>
TOTAL	600	600	600	500	500
NET BUDGET					
Poor Soils	+271	+81	-310	-4	-380
Fair Soils	+271	+60	-387	-4	-450
Good Soils	+271	+36	-475	-4	-530

\*Nitrogen lost varies with soil nitrogen content.

#Erosion values used are average values for loess uplands.

For dormant season underburns every 3-7 years, long-term nitrogen loss may be 3-5 percent of site total in fair and good soils and 6-8 percent in poor soils. Losses for growing season underburns every 5-7 years may be 7 percent in good soils, 8 percent in fair soils, and 13 percent in poor soils. Losses for growing season underburns every 3-4 years may be 12 percent in good soils, 15 percent in fair soils, and 22 percent in poor soils (appendix B).

#### Overall Risks

Long-term effects on nitrogen are combined with effects on soil biota, physical properties, and organic matter to judge overall risk to soil productivity. Risk of light slash burns is minimal on all soils. Risk of moderate slash burns is minimal on good and fair soils, and low on poor soils where they prevent long term soil recovery. Risk of severe slash burns is extreme on poor and fair soils, and high on good soils.

Risk to soil productivity from underburns depends on their frequency and season. For 5+ year underburns, risk from dormant season burns is minimal on good and fair soils and low on poor soils, while risk from growing season burns is low on good and fair soils and medium on poor soils. For 3-4 year underburns, risk from dormant season burns is minimal on good and fair soils and low on poor soils, where they prevent long-term soil recovery, while risk from growing season burns is medium on good and fair soils and extreme on poor soils. For 1-2 year underburns, risk from dormant season burns is medium on good soils, high on fair soils, and extreme on poor soils, while risk from growing season burns is extreme on all soils.

#### Mitigating Impacts

Severe burns are avoided by conducting slash burns so they do not consume all litter and duff and alter structure and color of mineral soil on more than 20 percent of the area. One way to achieve this result is to schedule slash burns 1-3 days after a soaking (0.5 inch or more) rain when soil, duff and large fuels are moist. In addition, poor soils can be protected by not burning any area with an average litter depth of less than 1/2 inch. For 3-4 year underburns, risk to soil productivity from growing season burns can be reduced to low on good and fair soils and high on poor soils by alternating them with dormant season burns. Mitigation measures required to protect soil from prescribed fire are in section II.E.

#### Data Gaps

Data are lacking on effects of severe slash burns on soil in the South. Underburns have been extensively studied, but studies of slash burns have been limited to light to moderate burns. Severe slash burns are analyzed as posing high to extreme risk to soil productivity, so data on their effects are important. The Council on Environmental Quality (CEQ) mandates a process for evaluating incomplete and unavailable information (40 CFR 1502.22).

To provide complete information, slash burns must be studied repeatedly on an array of poor, fair, and good soils in the South. The burns must be strictly controlled to produce severe effects. Such a comprehensive research program would cost several hundred thousand dollars and require 10 years or more. The Forest Service views these costs as too high to justify delay of this EIS.

The CEQ regulations require that existing credible evidence be summarized and impacts be analyzed using accepted methods. Existing data on effects of slash burns on soil are summarized in Appendix B. The method used to analyze impacts is:



1. Data on soil heating were compiled from slash burns in the Pacific Northwest and Australia and chaparral burns in the Pacific Southwest. These data were adjusted for southern burning conditions.

2. Data on effects of soil heating on organic matter and nitrogen were compiled from laboratory studies and the above field studies. These relationships were applied to typical levels of organic matter and nitrogen found in poor, fair, and good soils in the South to estimate degree of risk to soil productivity.

## **2. Effects of Mechanical Methods**

Mechanical methods may affect soil productivity through nutrient displacement, soil compaction, soil erosion, and nutrient leaching.

### **Nutrient Displacement**

Nutrient displacement is the movement of organic matter and nutrients offsite by dozer blades. Slash, litter and duff, and topsoil are moved into piles or windrows that occupy 5-10 percent of the site. Nutrients contained in the moved material are effectively lost to the site (Neary, Morris, and Swindel 1984). Raking moves nearly all litter and duff and up to two inches of topsoil, while piling moves only slash and some litter and duff.

Estimates of nitrogen lost by raking that moved 1 inch of topsoil range from 430 to 760 lb/ac (Burger 1979; Burger and Pritchett 1988; Neary, Morris, and Swindel 1984; Tew and others 1986; Tuttle, Golden, and Meldahl 1985). Burned windrows where about 0.5 inch of soil had been moved still had nitrogen contents of 230-330 lb/ac, despite large gaseous losses caused by burning (Morris, Pritchett, and Swindel 1983; Pye and Vitousek 1985). Large reductions in site pools of phosphorus, potassium, calcium, and magnesium were also reported. Reductions of nitrogen in litter and duff have ranged from 75 to 95 percent (Fox, Burger, and Kreh 1986; Morris and Pritchett 1983).

Raking may improve early stand growth by temporarily making nutrients more available and reducing competition. But later stand growth and long term soil productivity are reduced by nutrient deficiencies (especially of nitrogen and phosphorus) because organic matter that supplies nutrients over time is displaced offsite (Banker, Miller, and Davis 1983; Burger and Crutchfield 1986; Burger and Kluender 1982; Burger and Pritchett 1988; Pritchett and Morris 1982; Wells 1983). Growth losses of 20-50 percent have been measured in stands where 0.5-2.0 inches of topsoil had been removed before planting (Brendemuehl 1967; Dissmeyer 1985; Fox, Morris, and Maimone 1985; Haines, Maki, and Sanderford 1975; Pritchett 1981; Wilhite and McKee 1985).

Piling is estimated to move 90 percent of slash, 50 percent of litter and duff, and no soil from the site. Effects on site organic matter are minor and short term. About 300 lb/ac of nitrogen and 25 lb/ac of phosphorus might be removed.

Raking is estimated to move 90 percent of slash, litter and duff, and 0.4 inch of topsoil from the site. Major, long-term reductions of site organic matter occur. About 650-850 lb/ac of nitrogen and 35-40 lb/ac of phosphorus may be removed. Removal of potassium, calcium, and magnesium is 15-25 percent of site total.

#### Soil Compaction

Soil compaction is caused by the weight of machinery on the ground. It increases bulk density and decreases aeration porosity. Bulk density of undisturbed topsoil is commonly 1.00-1.20 g/cc; as it climbs to 1.40 g/cc, root growth is inhibited (Gent and Ballard 1985; Simmons and Ezell 1983). Aeration porosity (soil volume in pores larger than 0.05 mm) reflects a soil's ability to store and supply air, water, and nutrients. In undisturbed topsoil, it is commonly 20-25 percent. When it drops below 10 percent, root growth is restricted (Baver, Gardner, and Gardner 1972). Compaction also reduces populations of soil biota, with recovery taking 3-5 years (Smeltzer, Bergdahl, and Donnelly 1986).

Compaction is most severe in the top 3 inches of soil. It rarely occurs below 6 inches in harvest areas, can reach to 12 inches in major skid trails, and is negligible below 12 inches (Burger and others 1985). Compaction in skid trails exceeds threshold levels of bulk density (1.40 g/cc) and aeration porosity (10 percent) throughout the top 12 inches (Gent, Ballard, and Hassan 1983; Gent and others 1984; Gent and Morris 1986). Severe compaction in roads, skid trails, and log decks has been found to reduce volume of young pine stands by 50-70 percent (Hatchell, Ralston, and Foil 1970; Kreh, Burger, and Torbert 1985; Mitchell 1979; Perry 1964). It may take 20-40 years for severely compacted soils to recover (Perry 1964; Wells and Morris 1982).

Compaction hazard depends on soil type and moisture. Sandy soils do not have a plastic limit; they do not have enough clay to be compacted at any moisture level (Portland Cement Association 1973). Loamy and clay soils can be seriously compacted when soil moisture exceeds their plastic limit (Hatchell, Ralston, and Foil 1970; Moehring and Rawls 1970). The plastic limit varies from soil to soil, but is exceeded more of the time in clay soils and in floodplain and toeslope soils that receive extra moisture from upslope. Compaction hazard is highest for these soils and minimal for sandy soils.

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Compaction hazard also depends on ground cover and number of machine passes. Slash, litter and duff buffer the soil against vehicle pressures. Compaction increases with number of machine passes, although most is caused by the first three passes and little occurs after 10 passes (Burger and others 1985; Hatchell, Ralston, and Foil 1970; Kreh, Burger, and Torbert 1985; Moehring and Rawls 1970; Simmons and Ezell 1983). Compaction hazard is less for methods that remove little slash, litter and duff and require 1-2 passes than for those that remove much litter and duff and require several passes.

Studies of compaction by mechanical methods in the South are limited to chopping, raking, disking, and bedding. Chopping rarely increases bulk density or decreases aeration porosity (Blackburn, Wood, and DeHaven 1986; DeWitt and Terry 1983; Gent, Ballard, and Hassan 1983; Gent and others 1984; Gent and Morris 1986; Morris and Pritchett 1983; Pehl 1984; Slay and others 1987; Stransky 1981). Changes are limited to the 0-3-inch soil depth. Bulk density increases average less than 0.05 g/cc and never approach 1.40 g/cc. Aeration porosity declines by 0-3 percent. Compaction by mowing, ripping, shearing, and scarifying, which also remove no organic material and require only 1-2 passes, is also minimal. Ripping reduces compaction in the furrows.

Raking, which removes litter and duff and involves several passes, commonly increases bulk density and decreases aeration porosity (Blackburn, Wood, and DeHaven 1986; DeWitt and Terry 1983; Gent and Morris 1986; Morris and Pritchett 1983; Pehl 1984; Slay and others 1987; Stransky 1981; Tuttle, Golden, and Meldahl 1985). Changes are limited to the 0-3 inch soil depth. Bulk density increases average 0.15 g/cc and may reach 1.40 g/cc. Aeration porosity decreases by 5-6 percent and may drop below 10 percent. Raking may reduce rainfall infiltration by 50-80 percent (Banker, Miller, and Davis 1983).

Disking restores bulk density and aeration porosity in the 0-3 inch soil depth (Gent and others 1984). It should eliminate the shallow compaction caused by harvest and site preparation. Disking to at least 12 inches is required to eliminate the deep compaction on skid trails (Hatchell 1981).

Bedding restores bulk density and aeration porosity in the beds (DeWitt and Terry 1983; Gent, Ballard, and Hassan 1983). It should effectively mitigate the shallow compaction caused by harvest and site preparation. Beds must be at least 12 inches high to mitigate the deep compaction on skid trails (Hatchell 1981; Gent Ballard, and Hassan 1983).



Harvest may increase bulk density by 0.10 g/cc and decrease aeration porosity by 3-5 percent in the 0-3 inch soil depth (Gent, Ballard, and Hassan 1983; Gent and others 1984; Gent and Morris 1986). Mowing, chopping, ripping, shearing, and scarifying are estimated to increase bulk density by 0.03 g/cc and decrease aeration porosity by 2 percent. Piling, which removes most slash and some litter and duff, is estimated to increase bulk density by 0.10 g/cc and decrease aeration porosity by 4 percent. Raking, which removes all slash, litter and duff, is estimated to increase bulk density by 0.15 g/cc and decrease aeration porosity by 6 percent. Given pre-harvest values of 1.00-1.20 g/cc for bulk density and 20-25 percent for aeration porosity, risk of exceeding threshold bulk density or aeration porosity is minimal for mowing, chopping, ripping, shearing, and scarifying, low for piling, and medium for raking. Disking and bedding effectively mitigate compaction from harvest and site preparation.

Heavy equipment is not allowed on loamy or clay soils when the water table is within 12 inches of the surface or when soil moisture exceeds the plastic limit. This mitigation measure (section II.E) reduces risk from compaction in harvest areas to minimal for piling and low for raking.

#### Soil Erosion

Mechanical methods can cause soil erosion by exposing and tilling soil. Mowing exposes almost no soil, and ripping and scarifying increase surface storage, so these tools cause negligible erosion. Chopping, shearing, and piling expose little soil and cause minor erosion. Raking exposes much soil and can cause serious erosion. Soil tillage by bedding is offset by the increased surface storage it creates on level sites. Disking exposes and tills the most soil and causes the most erosion.



The effect of mechanical methods on ground cover was estimated from Dissmeyer and Stump (1978) as modified by erosion research (Beasley 1979; Beasley and Granillo 1985a, 1985b; Beasley, Granillo, and Zillmer 1986; Blackburn, Wood, and DeHaven 1986; Blackburn and others 1987; Douglass and Goodwin 1980; Pye and Vitousek 1985). USLE's cover factor is estimated at 0.000 for mowing, ripping, and scarifying; 0.003 for chopping, shearing, and piling; 0.015 for raking and bedding; and 0.060 for disking. Raking, bedding, and disking require 3 years for recovery, while the other tools require only 1 year. Potential erosion is shown in table IV-13.

**Nutrient Leaching** Leaching losses from mechanical methods increase with degree of site disturbance (Blackburn, Wood, and DeHaven 1985; Fox, Burger, and Kreh 1986; Hollis, Fisher, and Pritchett 1978; Morris, Pritchett, and Swindel 1983; Riekerk 1983; Vitousek and Matson 1984). Potential nitrogen losses may be 3 lb/ac for chopping, scarifying, ripping, shearing, and piling, 10 lb/ac for raking, and 20 lb/ac for disking and bedding. Losses of other, less mobile nutrients are negligible.

**Long-term Effects** Nitrogen budgets (table IV-14) show that timber harvest followed by piling produces neutral nitrogen budgets. Raking produces negative nitrogen budgets and causes long-term nitrogen depletion. Losses over one timber rotation amount to 25 percent of site total in poor soils, 18 percent in fair soils, and 15 percent in good soils. Nitrogen losses from other tools are negligible, less than 40 lb/ac.

**Overall Risks** Effects on nutrient pools and soil compaction are combined to judge overall risk to soil productivity from mechanical methods. Risk is minimal for mowing, chopping, ripping, shearing, scarifying, bedding, and disking. Risk of piling is minimal on good and fair soils, and low on poor soils where it prevents long-term soil recovery. Risk of raking is extreme on poor and fair soils and high on good soils.

**3. Effects of Herbicides** Effects of herbicides on soil are summarized by Neary and Michael (appendix C). Herbicides addressed in this EIS have no known effect on soil physical and chemical properties. Herbicides may affect soil productivity through biotic impacts, soil erosion, and nutrient leaching.

**Biotic Impacts** Depending on application rate and soil environment, herbicides can stimulate or inhibit soil organisms. Adverse effects are observed only at concentrations well above those found in forestry field studies. Use at typical rates required by mitigation measures (section II.E) does not reduce activity of soil biota (Fletcher and Friedman 1986; Greaves and Malkoney 1980). These herbicides are not general biocides but are formulated strictly to affect the more complex metabolic processes of higher plants that are absent in microflora (appendix C).

## Soil Erosion

Herbicides do not disturb soil, so treated areas usually have intact litter and duff that maintain erosion at low levels (appendix C). Selective treatments do not expose soil. Bare soil after broadcast treatments rarely exceeds 15 percent (Neary, Bush, and Grant 1986). USLE's cover factor is estimated to be 0.002 with recovery taking 1 year. Potential erosion from broadcast treatments is shown in table IV-13.

Tebuthiuron is an exception. Its high potency and persistence retard plant regrowth and interrupt litter cycling for several years (Elanco 1986). Use of tebuthiuron can significantly increase risk of erosion on steep slopes or erodible soils.

Pye and Vitousek (1985) found that broadcasting herbicides after raking and disking suppressed revegetation and produced 2.6 times the erosion of raking and disking alone. This effect was not noted after chopping, where litter and duff remained essentially intact. Broadcasting herbicides after raking, disking, or severe slash burns, which expose mineral soil over most of the area and rely on revegetation to reduce erosion, should at least double erosion from these practices.

## Nutrient Leaching

Nutrient leaching after herbicide use has been little studied. Based on nitrate losses found by Neary, Bush, and Douglass (1983), nitrogen losses are less than 10 lb/ac due to suppression of vegetation uptake. Losses of other, less mobile nutrients are negligible.

## Overall Risks

Nitrogen losses from erosion and leaching should not exceed 12 lb/ac. Nitrogen budgets over a timber rotation are positive and allow long-term nitrogen buildup. Overall risk to soil productivity from herbicides is minimal.

## 4. Effects of Biological Methods

Grazing can affect soil compaction, erosion, and nutrients. Degree of impact varies mostly with intensity of grazing.

### Soil Compaction

Compaction hazard from grazing depends on soil type and moisture, ground cover, and grazing intensity. Light to moderate grazing increases bulk density of topsoil by only 0.05-0.08 g/cc even when combined with burning every 3 years, and 1.40 g/cc is not approached. Light to moderate grazing combined with annual burning increases bulk density by 0.10-0.15 g/cc (Suman and Halls 1955). Aeration porosity declines by 0-4 percent. Heavy grazing (overgrazing) increases bulk density by 0.10-0.25 g/cc, often beyond 1.40 g/cc. Aeration porosity declines by 8-15 percent and may drop below 10 percent. Heavy grazing in the Blue Ridge Mountains reduced hardwood growth by 25-50 percent due to compaction. Removing livestock rectifies effects of overgrazing within 3 years (Blackburn 1984; Johnson 1952; Patric and Helvey 1986; Suman and Halls 1955; Wood and others 1987).



Harvest may increase bulk density by 0.10 g/cc and decrease aeration porosity by 3-5 percent in topsoil. Given pre-harvest values of 1.00-1.20 g/cc for bulk density and 20-25 percent for aeration porosity, risk from post-harvest grazing of exceeding threshold bulk density (1.40 g/cc) or aeration porosity (10 percent) is minimal for light to moderate grazing and high for overgrazing. Biological control for pine release requires heavy grazing, so risk to soil productivity from compaction is high.

#### Soil Erosion

Erosion rates from grazed land in the East range from 0.01 to 1.01 tons/ac/yr, but seldom exceed 0.30 tons/ac/yr with light to moderate grazing (Patric and Helvey 1986). In Texas grasslands, bare soil after 28 years of grazing occupied 0-3 percent of the area studied for light grazing, 6 percent for moderate grazing, and 25 percent for heavy grazing (Blackburn 1984). In Louisiana rolling uplands, moderate grazing increased erosion on plots from 0.05 to 0.07 tons/ac (Wood and others 1987).

The effect of heavy grazing on ground cover was estimated from Dissmeyer and Stump (1978). USLE's cover factor is given a value of 0.006. Potential erosion ranges from 0.08 tons/ac in the Atlantic flatwoods to 1.35 tons/ac in the Piedmont midlands.

#### Soil Nutrients

Moderate grazing may slightly increase nitrogen and phosphorus in topsoil (Wood and others 1987). Nutrient leaching from grazing in the South has not been studied. Nitrogen leaching from heavy grazing is assumed to be near that for raking (10 lb/ac). Losses of other, less mobile nutrients are negligible.

Nitrogen losses from erosion and leaching should total less than 16 lb/ac. Nitrogen budgets over a timber rotation are positive and allow long-term nitrogen buildup. The impact of biological methods on soil nutrients is minimal.

#### 5. Effects of Manual Methods

Effects of manual methods on soil are negligible. Litter and duff are left intact and revegetation is not suppressed. Risk of physical, chemical, or biological change is minimal.

#### G. WATER

Water quantity and quality can be changed by actions on the land. The degree of change determines the severity of effects on aquatic life. A key water quantity concern is the size and frequency of stormflows. Water quality is the physical, chemical, and biological purity of water. Even in undisturbed forests, floods occur and water is never pure. Concerns arise when channel stability, aquatic habitat, or water use is impaired.

Aquatic life includes fish and the plants and animals preyed on in a complex food web. The energy for this food web is supplied by organic matter delivered to or produced in the water. In streams shaded by riparian vegetation, the main source of organic matter is terrestrial leaves, branches, humus, and insects. In rivers, lakes, and ponds more exposed to the sun, the major source is aquatic plants.

Water quantity effects are analyzed as stormflow increases. In general, the references cited show that increases in total water yield are roughly proportional to increases in stormflow volume, especially in watersheds where most water yield occurs as stormflow. The analysis shows that such increases are small and short-lived except where intense mechanical tools, severe slash burns, or heavy grazing is used. These intensive tools generally increase stormflow but not baseflow because, in addition to reducing plant water use, they expose soil, reduce infiltration, and promote surface runoff.

Water quality effects are analyzed as increases in chemicals (herbicides, nutrients), sediment, and bacteria in water. The size of these increases depends greatly on use of mitigation measures (section II.E).

## **1. Effects of Herbicides**

Herbicides applied to the land may unintentionally enter surface or ground water. Herbicide use may also affect stream nutrients, stormflows, and sediment yields.

### **Surface Water**

Entry of herbicides to surface water is discussed in the Risk Assessment (appendix A) and by Neary and Michael (appendix C). Herbicides may enter streams during treatment by direct application or drift, or after treatment by surface or subsurface runoff. To pollute water, they must occur at concentrations high enough to impair water quality for human use or injure or kill aquatic plants or animals.

Direct application of herbicides to surface water occurs when streams are accidentally overflowed during aerial application. Risk is highest on utility lines where flight paths cross many streams, and less in timber stands where flight paths are laid out to avoid streams. Peak concentrations depend mostly on application rate and degree of overflight, and have commonly been 2.100 to 2.400 ppm in field studies where overflight was substantial (appendix C). This agrees with a recent field study of glyphosate (Payne, Feng, and Reynolds 1987). Concentrations drop below 0.050 ppm onsite within 1-2 days and decrease rapidly downstream due to mixing and dilution. But some aquatic plants and animals may be injured or killed onsite.

Drift of herbicides into surface water depends mostly on application method, existence of buffers, and weather. Drift occurs only in foliar applications, is greater for broadcast than selective treatments, increases from hand to mechanical to aerial tools, and decreases from small to large droplets to granules. Drift increases with wind, but buffers moderate its effects. Peak concentrations in streams from aerial spraying of fine droplets with 50-70 foot buffers have commonly been 0.130 to 0.148 ppm in field studies (appendix C). Mitigation measures (section II.E) require buffers of 100 feet (aerial) and 30 feet (ground) and nozzles producing large droplets, so peak concentrations from aerial drift should rarely exceed 0.050 ppm (appendix A). Applying glyphosate as large droplets by air with an 82-foot buffer produced a peak concentration of only 0.002 ppm (Payne, Feng, and Reynolds 1987).

After treatment, herbicides may enter streams by subsurface flow or by movement in ephemeral channels. Key factors affecting peak concentration are presence of buffers, storm size, herbicide application rate and properties (mobility and persistence), and downstream mixing and dilution.

Perennial and intermittent streams are protected by 30-foot (ground) and 100-foot (aerial) buffers. Herbicides applied along these streams must move through the buffer and are subject to dilution and mixing in transit. Ephemeral streams often are not buffered. Herbicides applied directly to them are usually picked up in streamflow by the first storm large enough to create flow in the channels.

Large storms rarely produce high herbicide concentrations in streams because herbicides are diluted by large water volumes. Small storms may not produce enough flow to move herbicides into streams. Intermediate storms produce highest concentrations.

Potential herbicide concentration in streams is proportional to application rate. Typical rates required by mitigation measures (section II.E) are 0.1-4.0 lb/ac except for fosamine and are a fraction of the label rate. Selective treatment further reduces rates by 40-70 percent.

Herbicide mobility and persistence affect potential entry to streams. Herbicide mobility depends on water solubility and adsorption (soil bonding) tendency. The potentially most mobile herbicides are 2,4-D (extreme solubility, low adsorption), picloram (high solubility, low adsorption), and hexazinone (moderate solubility, minimal adsorption). On the other hand, 2,4-DP, sulfometuron methyl, and triclopyr have minimal solubility, and fosamine and glyphosate are extremely adsorptive (appendix C, table 1).



Herbicide persistence depends on modes and rates of degradation. Tebuthiuron is extremely persistent (half-life 392 days), because it degrades slowly and only by microbial action. Picloram and glyphosate are moderately persistent (half-life 60-65 days). Picloram degrades mainly by direct sunlight, and microbial degradation is slow. Glyphosate degrades mainly by microbial action but not by sunlight. On the other hand, persistence of 2,4-DP, fosamine, and sulfometuron methyl is minimal (half-life 10 days), due mainly to rapid microbial degradation (appendix C, table 1).

Based on the mobility and persistence of the evaluated herbicides, those with the most potential for movement to streams through buffers are 2,4-D, picloram, and hexazinone. In field studies where herbicides were applied at typical rates using typical buffer widths, peak concentrations in streams have been less than 0.050 ppm (appendix C). Despite its extreme persistence, tebuthiuron has only moderate potential for movement to streams due to its low solubility and moderate adsorption. Glyphosate has low movement potential because its moderate persistence is more than offset by its extreme adsorption.

Herbicide mobility has less effect on levels of herbicides in ephemeral streams, because buffers are seldom used and herbicides may be applied directly to the channel. Persistence is important because it determines how much herbicide is still present in the channel when the next flow-producing storm occurs. Herbicides can be mobilized in solution or with sediment. Peak concentrations in field studies have ranged from 0.180 to 0.550 ppm (appendix C).

Dilution through water inflow and mixing by turbulence rapidly reduce herbicide concentrations downstream. As watershed size doubles, peak herbicide concentration should drop to 1/4 its initial level (Neary, Bush, and Douglass 1983). For example, a peak concentration of 0.500 ppm in an unprotected ephemeral stream with a 10-acre watershed will likely drop to 0.050 ppm by the time it reaches a small perennial stream with a 50-acre watershed and 0.001 ppm in a large stream with a 2,500-acre watershed.

Mitigation measures (section II.E) require buffers along perennial and intermittent streams, and mixing and dilution rapidly reduce concentrations delivered by ephemeral streams. Peak concentrations of some herbicides in small, headwater perennial streams due to drift or runoff may range up to 0.050 ppm in some cases. Applying EPA's strictest drinking water standard (0.100 ppm for 2,4-D) across the board, these concentrations pose minimal risk to water quality for public health or aquatic plants and animals. For example, 0.926 ppm of hexazinone do not affect aquatic algae, invertebrates, or fish (Neary, Bush, and Douglass 1983). Since picloram affects many vegetable crops at

concentrations as low as 0.010 ppm (Baur, Bovey, and Merkle 1972), it should be used with care near water used for irrigation.

Accidental direct application to streams occurs on some aerial treatments, especially utility lines. Risk to water quality is generally minimal where mixing and dilution are substantial, as in municipal watersheds whose reservoirs exceed 5 acre-feet. But tebuthiuron poses high risk due to its extreme persistence; 28 percent remains after 2 years, and 2 percent after 5 years.

Effects on wetland vegetation are minimal because buffers keep herbicide concentrations below 0.050 ppm. Mixing and dilution reduce herbicide concentrations to 0.001 ppm long before they reach rivers or estuaries, so effects on them are negligible.

#### Ground Water

Entry of herbicides to ground water is discussed in the Risk Assessment (appendix A) and by Neary and Michael (appendix C). After treatment, herbicides may move into aquifers by vertical seepage. To pollute ground water, they must occur at concentrations high enough to impair water quality for human use. Key factors affecting peak concentration are herbicide application rate and properties (mobility and persistence), soil type, depth to water table, and distance to point of use.

Potential herbicide concentration in ground water is proportional to application rate. As discussed earlier, typical rates are a fraction of the label rate, and selective treatment further reduces rates by 40-70 percent.

Herbicide mobility and persistence affect potential for seepage. Mobility depends on solubility and adsorption, and persistence depends on degradation mode and rate. As discussed earlier, the potentially most mobile herbicides are 2,4-D, picloram, and hexazinone, and the most persistent ones are tebuthiuron, picloram, and glyphosate. Mobility and persistence properties suggest that herbicides with at least a moderate seepage potential include 2,4,-D, dicamba, hexazinone, imazapyr, picloram, and tebuthiuron.

Herbicides move most easily through sand, which is most porous and has the least adsorption potential. Potential for ground water contamination increases as depth to water table and distance to point of use decrease.

The risk assessment (appendix A) models herbicide contamination of ground water under conditions likely to produce high concentrations. Herbicides are applied at maximum rates to the soil surface. They are then leached through 3 feet of sandy loam soil by 50-60 inches of annual rainfall. The water table is only 3 feet deep, and the

aquifer is sand. In the model, only dicamba, hexazinone, imazapyr, picloram, and tebuthiuron reach the shallow water table even 10 percent of the time. Concentrations in ground water directly under the treated area exceed 0.001 ppm only for hexazinone (0.004), dicamba (0.005), and tebuthiuron (0.008). Only tebuthiuron, with its 392-day half-life, moves outside the treatment area; maximum concentration 330 feet away is 0.002 ppm 1 year after treatment.

Field studies of herbicides applied at typical rates show that 2,4-D, sulfometuron methyl, and triclopyr do not seep to shallow ground water, and hexazinone reaches peaks of less than 0.025 ppm. Applied at typical rates, picloram concentrations in shallow ground water should be just as low (appendix C).

Applied at typical rates, herbicides should not occur in shallow ground water at concentrations exceeding a small fraction of EPA's strictest drinking water standard. Deeper aquifers tapped by wells should have negligible concentrations. Risk to ground water quality is minimal, especially since mitigation measures (section II.E) require a buffer around all water sources that reduces herbicide concentrations through mixing and dilution. But tebuthiuron, due to its extreme persistence, may build up in shallow ground water if used every few years on utility lines.

#### Stream Nutrients

Broadcast use of herbicides may produce minor increases in stream nutrients such as nitrates. Increases are short-lived due to minimal soil disturbance and prompt plant regrowth. Drinking water standards are not exceeded if mitigation measures (section II.E) are employed (Neary, Bush, and Grant 1986).

#### Stormflows

Effects of herbicides on stormflows are rather minor because soil infiltration capacity is usually maintained (Blackburn and others 1984). Selective application does not increase stormflows because plant water use is little affected. Broadcast application may produce small increases by reducing plant water use, with typical increases in stormflow volumes and peaks of about 40 percent for 1 year in small (1-3 acre) watersheds (Neary, Bush, and Grant 1986).

Tebuthiuron may produce larger increases. Its high potency and persistence retard plant regrowth and interrupt litter cycling for several years (Elanco 1986). Bare soil and surface runoff may increase substantially.

#### Sediment Loads

Sediment is produced by surface and channel erosion. Surface erosion is minimal in undisturbed forests and is caused by soil exposure and tillage. Channel erosion occurs even in undisturbed forests and increases with peak flows.



Potential surface erosion is shown in Table IV-13. Only a fraction of surface erosion becomes sediment. This fraction (sediment delivery ratio) increases with steeper slopes and denser drainage networks and is reduced by buffers along streams. Because perennial and intermittent streams are protected by buffers, eroded soil is delivered almost solely to ephemeral streams. Data on average slope steepness and drainage density were used to derive sediment delivery ratios (appendix B) and sediment yields from surface erosion for the various landtypes (Table IV-15).

Data isolating channel-eroded sediment from surface-eroded sediment are scarce. Channel sediment increases with peak flow. Increases from broadcast herbicide application should be proportional to increases in peak flow, or about 40 percent for 1 year (Neary, Bush, and Grant 1986).

## **2. Effects of Mechanical Methods**

Mechanical methods may increase stream nutrients, stormflows, and sediment loads. In general, amount of increase depends on degree of disturbance, topography, and soil type.

### **Stream Nutrients**

Mechanical methods may increase stream concentrations of some nutrients. Drinking water standards are not exceeded if mitigation measures (section II.E) are employed (Fox, Burger, and Kreh 1986; Hewlett 1979; Hollis, Fisher, and Pritchett 1978; Riekerk 1985). Many aquatic systems are nutrient poor, so small increases in nutrients often improve their productivity.

### **Stormflows**

Mechanical methods can increase stormflow volumes and peaks in small (1-12 acre) watersheds. Mowing causes no increases because it exposes little soil and does not reduce water use by plants. Ripping and scarifying cause no increases because soil disturbance is offset by increased surface storage (Miller 1984). Chopping, shearing, bedding, and piling retain soil infiltration capacity and cause small increases by reducing water use by vegetation. Typical increases in stormflow volumes and peaks are 40 percent for these four tools, and they last one year. Disking and raking cause larger increases by reducing infiltration and promoting surface runoff. Typical increases are 200 percent and may last three years or more (Beasley and Granillo 1985a; Blackburn, Wood, and DeHaven 1986; Blackburn and others 1987; Douglass, Van Lear, and Valverde 1983; Swindel, Lassiter, and Riekerk 1983a, 1983b; Ursic 1986; Van Lear and Douglass 1982). Large stormflow increases may affect aquatic biota by eroding and baring streambanks and by scouring and silting streambeds.

### **Sediment Loads**

Mechanical methods can increase sediment loads from both surface and channel erosion in small (1-12 acre) watersheds. Amount of increase is related to degree of disturbance (Beasley 1979; Beasley and Granillo 1985a, 1985b; Beasley, Granillo, and Zillmer 1986; Blackburn, Wood, and DeHaven 1986; Blackburn and others 1987; Douglass and Goodwin 1980; Ursic 1986).

Table IV-15.--Sediment delivery ratios and sediment yields (tons per acre) for treatments by landtype

<u>Landtype</u>	<u>Sediment Delivery Ratio</u>	<u>-----Sediment Yield (tons/acre)-----</u>			
		<u>Mod. Burns</u>	<u>Chop-Shear</u>	<u>Severe Burns</u>	<u>Heavy</u>
		<u>Herbicides</u>	<u>Pile</u>	<u>Rake-Bed</u>	<u>Disk</u>
COASTAL PLAIN					
Oak Savannas	.03	.0030	.0045	.0225	.0903
Upper Hills	.05	.0120	.0185	.0915	.3665
Rolling Uplands	.03	.0033	.0051	.0249	.0990
Clay Flatlands	.01	.0006	.0009	.0047	.0187
Loess Uplands	.05	.0180	.0270	.1360	.5440
Mississippi Valley	.01	.0003	.0005	.0025	.0101
Gulf Flatwoods	.01	.0003	.0005	.0024	.0096
Atlantic Flatwoods	.01	.0003	.0004	.0020	.0081
Sand Ridges	.01	.0004	.0007	.0033	.0134
PIEDMONT:	.06	.0270	.0402	.2022	.8088

Sediment delivery ratios were applied to erosion rates to derive sediment yield from surface erosion for the various landtypes (Table IV-15). Channel sediment tends to increase in proportion to peak flow (Blackburn, Wood, and DeHaven 1986; Blackburn and others 1987), with first-year increases of about 40 percent for chopping, shearing, bedding, and piling, and 200 percent for disking and raking.

Large sediment increases may block sunlight, impair photosynthesis by algae and aquatic plants, and erode gill filaments of fish and aquatic invertebrates. Once deposited, the sediment can bury aquatic plants and insects, be imbedded in spawning gravels to smother eggs and prevent fry emergence, and fill in deep pools that are vital for fish cover.

### 3. Effects of Prescribed Fire

Prescribed fire may increase stream nutrients, stormflows, and sediment loads. In general, amount of increase depends on fire severity.

#### Stream Nutrients

Slash burns may produce minor increases in concentrations of some nitrogen compounds and cations, but drinking water standards are not exceeded even by severe burns. Underburns and grassland burns have negligible effect (appendix B).

#### Stormflows

Moderate slash burns may increase stormflow volumes and peaks by about 40 percent for 1 year by reducing water use by remaining vegetation. Severe burns cause greater, more prolonged increases by exposing mineral soil and promoting surface runoff (appendix B).

Underburns and grassland burns are light to moderate. Underburns do not affect water use, and grassland burns only affect it for a few weeks until grass regrows. These burns do not affect stormflows (appendix B).

#### **Sediment Loads**

Sediment delivery ratios were applied to erosion rates to derive sediment yield from surface erosion for the various landtypes (Table IV-15). Channel sediment increases in proportion to peak flow (Ursic 1970), with first-year increases of about 40 percent for moderate slash burns and 200 percent for severe slash burns.

#### **4. Effects of Biological Methods**

Grazing minimally increases stream concentrations of nutrients. Livestock with access to streams increase harmful bacteria in the water, which may remain elevated for months after livestock removal if animal wastes are dropped in or next to the channel. When livestock are prevented from concentrating near streams, animal wastes are processed by litter, duff, and soil and counts of aquatic bacteria rarely exceed water quality standards (Patric and Helvey 1986; Tiedemann and others 1987). Mitigation measures (section II.E) require livestock to be managed to reduce water contamination and streambank damage, so risk to public health is generally low.

Light to moderate grazing commonly reduces soil infiltration capacity by less than 50 percent. Heavy grazing reduces it by 50-90 percent (Blackburn 1984; Patric and Helvey 1986; Wood and others 1987). In Oklahoma and Texas grasslands, 20-30 years of continuous overgrazing increased runoff by more than 100 percent and sediment yield by 10-26 times above moderate rotation grazing (Blackburn 1984).

Heavy grazing increases stormflows by reducing soil infiltration capacity and plant water use. The heavy grazing required for pine release may produce sediment yield from surface erosion ranging up to 0.081 tons per acre. Channel sediment increases in proportion to peak flow, estimated to be about 200 percent declining over 3 years.

#### **5. Effects of Manual Methods**

Manual methods do not increase peak flows because plant water use is little affected. Stream nutrients and sediment loads are not increased because litter and duff are left intact and revegetation is not suppressed.

#### **6. Watershed Analysis**

Cumulative effects on water are the combined effects of vegetation management and timber harvest onsite, plus those of all other management on all other land in a watershed. All these effects must be integrated and compared with tolerance limits for the watershed. Cumulative effects analyzed are increased herbicide concentrations, stormflows, and sediment loads.



Cumulative effects were analyzed on typical watersheds in the Coastal Plain/Piedmont. Two large (20,000+ acre) watersheds were used to assess cumulative effects heavily influenced by private management. Eight small (4,400-8,500 acre) watersheds that represent the array of landtypes were used to assess cumulative effects dominated by Forest Service management (Table IV-16).

Cumulative effects are most rigorously analyzed on the 8 small watersheds. Forest Service land makes up most of their area and downstream mixing and dilution are limited. They were chosen to represent differences in topography, earth materials, and runoff-erosion response to management. Figure IV-3 shows the landtypes in the Coastal Plain/Piedmont and throughout the South.

Herbicides used on national forests are applied at low rates, separated from perennial and intermittent streams by buffers, and subject to considerable downstream mixing and dilution. In the maximum herbicide alternatives (G and H), assuming all eligible acres are treated in the same year, less than 10 percent of the watershed is herbicide-treated on national forest land in every watershed except Hager Creek (17 percent) and Ninemile Creek (11 percent). Maximum herbicide concentrations at the mouth of the watersheds due to national forest use should never exceed 0.025 ppm unless herbicides are accidentally applied directly to surface water.

Herbicides used on private farmland are usually applied every year, at higher rates, and along streams with narrow or no buffers. Peak concentrations measured in runoff range from 1.800 to 5.200 ppm (Wauchope 1978). Considered alone or in addition to other management, risk to water quality from typical application on Forest Service land is minimal.

Timber harvest increases stormflow volumes and peaks in proportion to percent of stems cut. Increases from clearcut 1-16 acre watersheds average 40 percent for 1 year (Douglass, Van Lear, and Valverde 1983; Settergren and Krtansky 1978; Ursic 1970). Additional first year increases are: 40 percent for broadcast herbicides, chopping, shearing, piling, bedding, and moderate slash burns; and 200 percent for disking, raking, severe slash burns, and heavy grazing.

Stormflow peaks are subject to considerable flattening downstream from turbulence and dilution. Increases from clearcut 74-108 acre watersheds average only 5-10 percent for one year (Hewlett and Helvey 1970; Patric 1980; Reinhart, Eschner, and Trimble 1963). Unchanged flows coming from undisturbed portions of a watershed further moderate increases from disturbed portions. In the maximum treatment alternative (H), stormflow increases at the mouth of the watersheds due to national forest management are 2-7

Table IV-16.--Land use data for typical watersheds, cumulative water effects

Watershed	Landtype	National Forest	Total Acres	N.F. Acres	-----Private Acres-----		
					Timber	Crop	Pasture
BRUSHY CK.	COASTAL PLAIN	Homochitto	23,860	16,240	6,900	290	430
Payne L.	Upper Hills	Talladega	7,890	7,810	80	0	0
Cottonwood Ck.	Oak Savannas	LBJ	8,500	5,100	170	80	3,150
Hager Ck.	Rolling Uplands	Davy Crockett	5,200	3,600	1,080	50	470
Red Prong	Loess Uplands	Homochitto	4,700	3,660	950	0	90
Buck Br.	Clay Lowlands	Bienville	8,110	7,020	770	160	160
Ninemile Ck.	Sand Ridges	Ocala	4,400	4,190	210	0	0
Two Barrel Br.	Flatwoods	Apalachicola	4,600	4,520	80	0	0
<hr/>							
INDIAN CK	PIEDMONT	Sumter	54,600	30,800	14,280	4,760	4,760
Patterson Ck.	Midland Plateau	Sumter	6,400	5,500	600	200	100

percent except for Hager Creek (20 percent). Adding the effects of private land management, stormflow increases range from 3 to 33 percent.

This analysis inflates estimates of stormflow increases because it assumes that maximum rates of timber harvest are used, all eligible acres are treated in the same year, and stormflows from national forest and private lands are synchronized. These increases represent average-sized stormflows. Increases during large floods, which occur when soils over the entire watershed are saturated, would be much less.

#### Sediment Loads

Channel erosion occurs even in undisturbed forests, and is generally lowest in the level channels of the Lower Coastal Plain and highest in the steeper, erodible channels of the loess uplands. Typical annual sediment yields from channel erosion in undisturbed small watersheds in good hydrologic condition are 20 lb/ac in the lower Coastal Plain, 120 lb/ac in the loess uplands, and 40 lb/ac elsewhere (Beasley 1979, 1982; Beasley and Granillo 1985a, 1985b; Beasley, Granillo, and Zillmer 1986; Blackburn, Wood, and DeHaven 1986; Blackburn and others 1987; DeHaven and others 1984; Dendy, Ursic, and Bowie 1979; Douglass, Van Lear, and Valverde 1983; Hewlett 1979; Riekerk 1983; Schreiber and Duffy 1982; Ursic 1970, 1986; Van Lear and others 1985).

Channel erosion increases in proportion to peak flow. In this analysis, clearcuts are estimated to increase channel sediment an average of 40 percent for 1 year. Additional increases are estimated to be: 40 percent for broadcast herbicides, chopping, shearing, piling, bedding, and moderate slash burns; and 200 percent for disking, raking, severe slash burns, and heavy grazing. Increases in channel sediment are estimated at 40 percent for pasture land and 200 percent for cropland.

In addition to vegetation management, surface-eroded sediment is increased by timber harvest, agricultural use, and roads. Typical rates of surface erosion for these uses were combined with sediment delivery ratios for the various landtypes to estimate surface-eroded sediment. Estimates of channel and surface sediment were combined to derive total 10-year sediment yield for each watershed (Table IV-17).

High rates of timber harvest and alternative H were modeled to show a maximum effect. Channel erosion was computed by multiplying acres treated by the proper increase rate for each practice. Surface-eroded sediment was computed as follows:

1. For roads, acres of road were multiplied by typical erosion rates for dirt, gravel, and paved roads. Existing roads are permanent and erode every year. New timber access roads are temporary and erode for only 1 year.
2. For timber harvest, cropland, and pasture, acres treated were multiplied by USLE factors for each watershed. Cover factors (USFS and private) are 0.002 and 0.005 for timber harvest, 0.003 and 0.006 for pasture, and 0.020 for cropland (Dissmeyer and Stump 1978). Skid trails, with higher erosion rates, cover 5 and 10 percent of timber harvest. Cropland and pasture erode every year but timber harvest normally erodes for only 1 year.
3. For vegetation management (alternative H), acres treated were multiplied by erosion values in table IV-13. On private forest land, site preparation was assumed to be all disking, and the resulting erosion was added to private timber harvest in the "forest" category.
4. In each category, the computed erosion was multiplied by a sediment delivery ratio (SDR) to derive the sediment values in table IV-17. The SDR assumes a sediment source zone whose width in feet is 50 plus 3.0 times percent slope for roads and 40 plus 1.4 times percent slope for areal treatments (Swift 1986). Filter strips occur along perennial and intermittent streams on national forests, perennial streams only on private forest land, and seldom on private crop and pasture land.

For each watershed, table IV-17 shows natural sediment yield and the contribution of each management category. The total man-caused sediment is shown and expressed as a percent increase above natural sediment.

A chief concern of increased sediment is its effect on quality of aquatic habitat. Risk to habitat quality is rated as minimal for increases of 0-100 percent, low for 100-200 percent, medium for 200-300 percent, high for 300-400 percent, and extreme for increases greater than 400 percent (Alexander and Hansen 1986).



# USFS SOUTHERN

## LEGEND

#### 'W' APPALACHIAN PLATEAUS PROVINCE

## 1 CUMBERLAND PLATEAU

- a Kentucky Basin
- b Tennessee Plateau
- c Table Plateaus

## 2 CUMBERLAND MOUNTAINS

### **T COSTAL PLAIN PROVINCE**

# 1 UPPER HILLS

## 2 MIDDLE COASTAL PLAIN

- a Oak Savannahs
- b Clay Flatlands
- c Rolling Uplands
- d Loose Uplands
- e Limestone Plains

**75 BLUE RIDGE PROVINCE**

# 1 NARROW RIDGE

## 2 BLUE RIDGE MOUNTAINS

### 3 UNAKA MOUNTAINS

### 3 LOWER COSTAL PLAIN

- a Rio Grande Plains
- b Gulf Flatwoods
- c Atlantic Flatwoods
- d Mississippi Valley
- e Limestone Serfs
- f Sand Ridges
- g Tropical Swamps

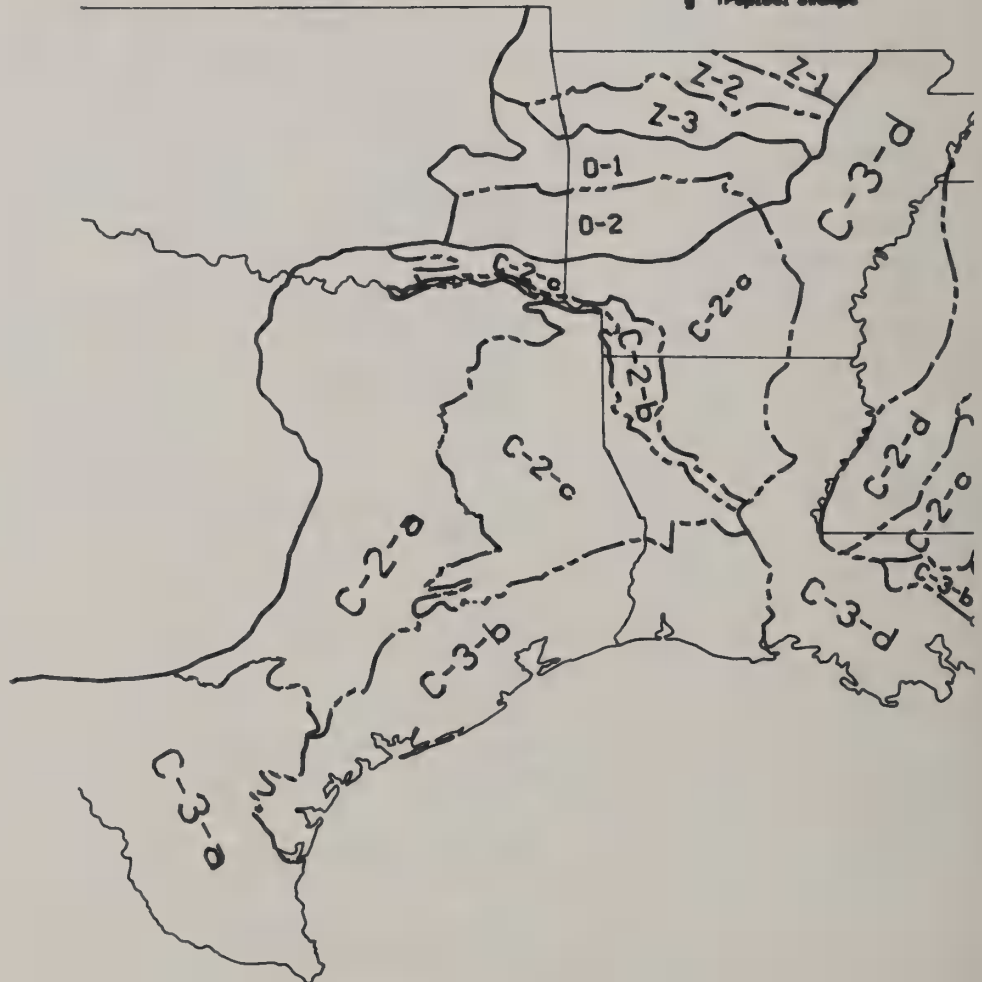


Figure IV-3.--Landtypes of the Southern Region

# REGION LANDTYPES

"I" INTERIOR LOW PLATEAUS PROVINCE

**'O' QUACHITA PROVINCE**

- 1 ARKANSAS VALLEY  
2 OUACHITA MOUNTAINS

## 7. RIDGE AND VALLEY PROVINCE

- 1 FOLDED HIGHLANDS  
2 FAULTED LOWLANDS

## 'Z' OZARK PLATEAUS PROVINCE

- 1 SALEM PLATEAU  
2 SPENFIELD PLATEAU  
3 BOSTON MOUNTAINS

**7<sup>th</sup> PIEDMONT PROVINCE**

- 1 UPLAND FOOTHILLS
- 2 MIDLAND PLATEAU
- 3 TRIASSIC LOWLANDS

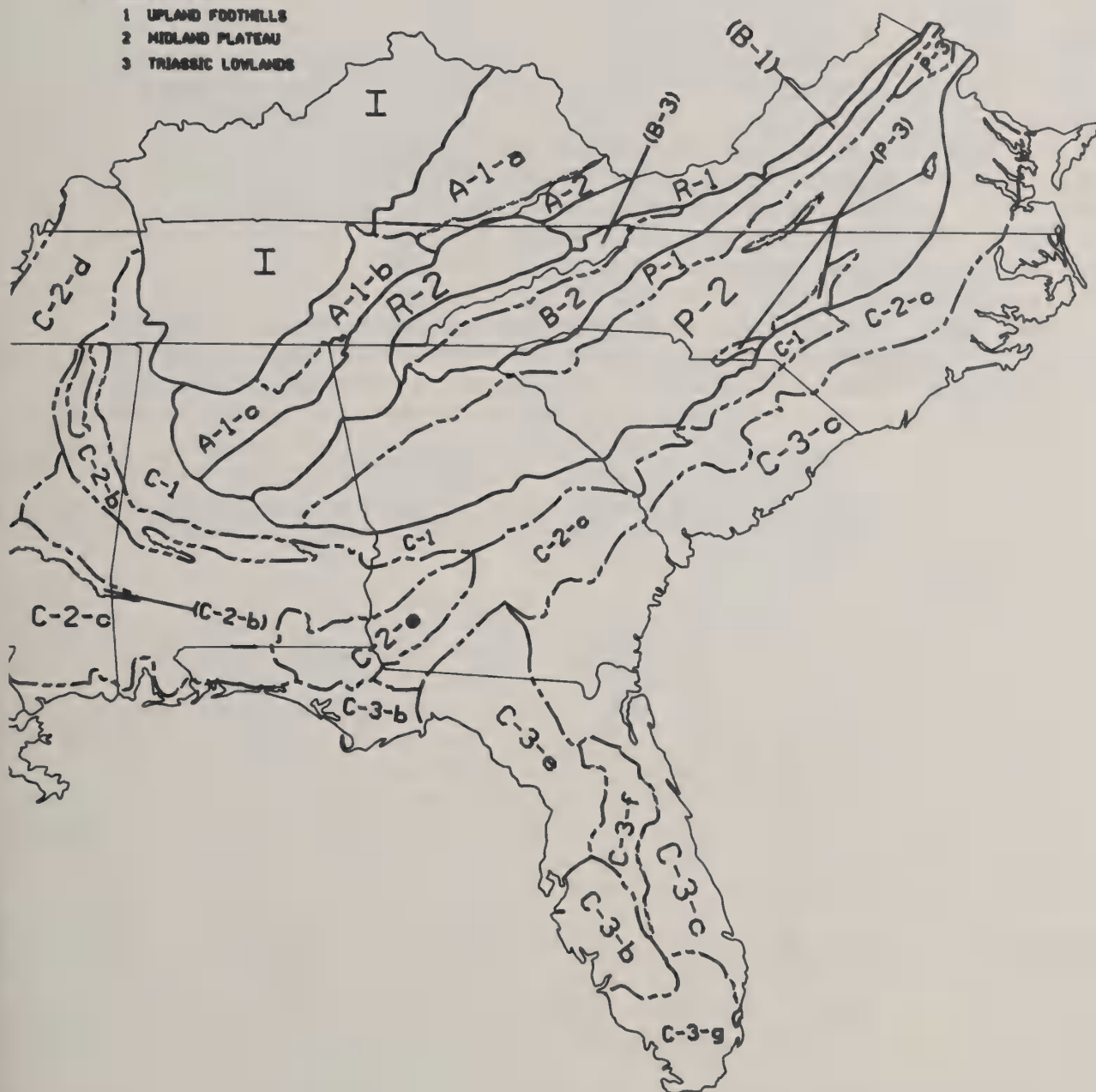


Table IV-17 shows that for all watersheds in the Coastal Plain, risk to aquatic habitat from sediment is minimal. Increases are especially small on watersheds with little private land or with flat topography.

In the Piedmont, risk is low on the small watershed and extreme on the large watershed. In both cases, half of the sediment increase comes from private cropland, where rate of surface erosion is estimated as 4.5 tons per acre per year. Sediment from vegetation management is only 1-3 percent of the total increase and does not worsen risk to aquatic habitat or biota.

## **7. Data Gaps**

Data are lacking that isolate effects of vegetation management on channel sediment in the South. Effects on stormflows have been studied, but channel sediment has seldom been isolated from surface-eroded sediment. Because channel sediment makes up a sizeable share of total sediment load, data on how management affects it are important. The Council on Environmental Quality (CEQ) mandates a process for evaluating incomplete and unavailable information (40 CFR 1502.22).

To provide complete information, timber harvest and vegetation management activities must be studied on an array of landtypes in the South. Studies must be strictly controlled to isolate channel sediment due to increased stormflows from sediment due to surface erosion. Such a research program would be very difficult to implement, cost several hundred thousand dollars, and require 10 years or more. The Forest Service views these costs as too high to justify delay of this EIS.

CEQ regulations require that existing credible evidence be summarized and impacts be analyzed using accepted methods. Existing studies where surface erosion was essentially absent suggest that channel sediment increases roughly in proportion to peak flow. The processes involved are well understood but complex, so we have expressed percent increase in channel sediment as equal to percent increase in peak flow for ease of explanation. For example, chopping increases peak flow an average of 40 percent and so is estimated to increase channel sediment by 40 percent.

## **H. AIR QUALITY**

Air is a dynamic resource whose quality fluctuates over time and space. Key air quality concerns are concentrations of gases and particulates that may impair human health and welfare. Prescribed fire is the only vegetation management method that emits substantial amounts of gases and particulates to the atmosphere. Prescribed fire presently occurs on about 10 percent of national forest lands in the Coastal Plain/Piedmont each year. On a given site, slash burns may occur once every 40-80 years and underburns every 3-7 years. Effects on air quality are brief and intermittent in each area affected.



Periodic fires have played an important role in the formation and maintenance of Coastal Plain/Piedmont ecosystems (Komarek 1968; Kozlowski and Ahlgren 1974; Wade 1983). Coastal Plain pine forests are naturally fire-dependent (Braun 1950; Oosting 1956). The air quality of the region has thus been subject to the influence of wildland fires for thousands of years.

Wildfires emit the same pollutants as prescribed fires. In general, emissions from wildfires are greater per acre burned and often occur at times when winds may carry smoke directly into sensitive areas. Smoke dispersion is also impaired when wildfires burn into the night (Sandberg and Ward 1981).

Any wildland fire burns in 4 phases (McMahon 1983; National Wildfire Coordinating Group 1985; Sandberg and others 1979). During preignition, fuels ahead of the fire are heated and dried and gases are released. During flaming combustion, temperatures rise rapidly, gases are flamed, and black smoke dominated by solid soot particles is produced. During smoldering combustion, temperatures drop and gases condense to produce white smoke composed mostly of liquid tar droplets. Smoldering emits 2-5 times the particulates as flaming. During glowing combustion, all combustible gases have been driven off, no visible smoke is produced, and carbon monoxide and carbon dioxide are the chief emissions.

Table IV-17.—Cumulative 10-year sediment yields (tons) for typical watersheds

	<u>BRUSHY</u>	<u>Payne</u>	<u>Cottonwood</u>	<u>Hager</u>	<u>Red Prong</u>	<u>Buck</u>	<u>Ninemile</u>	<u>Two Barrel</u>	<u>INDIAN</u>	<u>Patterson</u>
NATURAL	14,316	1,578	1,700	1,040	2,820	811	440	460	10,920	1,280
USFS: Roads	106	38	14	36	87	16	9	7	4,700	436
Harvest	<u>269</u>	<u>21</u>	<u>230</u>	<u>31</u>	<u>42</u>	<u>4</u>	<u>4</u>	<u>4</u>	<u>293</u>	<u>35</u>
	375	59	244	67	129	20	13	11	4,993	471
PVT: Roads	424	12	17	91	24	6	1	2	2,218	144
Forest	3,500	51	28	97	487	7	3	2	9,005	378
Cropland	1,469	0	78	52	0	58	0	0	27,948	1,174
Pasture	<u>674</u>	<u>0</u>	<u>726</u>	<u>153</u>	<u>141</u>	<u>19</u>	<u>0</u>	<u>0</u>	<u>8,461</u>	<u>178</u>
	6,067	63	849	393	652	90	4	4	47,632	1,874
ALT. H	413	27	10	75	64	10	8	9	544	65
TOTAL INCREASE	6,855	149	1,103	535	845	120	25	24	53,169	2,410
PERCENT INCREASE	(48)	(9)	(65)	(51)	(30)	(15)	(6)	(5)	(487)	(188)

## 1. Gases

EPA considers some gases emitted by prescribed fire (carbon monoxide, hydrocarbons, nitrogen and sulfur oxides, and photochemical oxidants) to be pollutants (McMahon 1981). Emission of these gases by prescribed fire, summarized by McMahon (1983), National Wildfire Coordinating Group (1985), Sandberg and Ward (1981), Sandberg and others (1979), USDA Forest Service (1976), and Van Lear and Johnson (1983), is discussed below. Health risk to workers and the public from burning herbicide-treated vegetation is negligible (section IV.B).

### Carbon Monoxide

This colorless, odorless, toxic gas is the most abundant air pollutant from forest fires. Its adverse effect on human health depends on exposure time, level of physical exertion, and concentration of gas. Typical emission factors range from 40 lb per ton of fuel consumed during flaming, to 200 lb/ton during smoldering, to 500 lb/ton in smoldering slash piles and organic soil. Concentrations may be 100-200 ppm at the fireline but diluted to less than 10 ppm about 100 feet downwind, so public health hazards are negligible.

### Hydrocarbons

Hydrocarbons contain hydrogen, carbon, and sometimes oxygen. Typical emission factors are 30-100 lb/ton of fuel consumed, with most produced during smoldering. Most hydrocarbons have no harmful effect, but several, called polycyclic organic matter (POM), are carcinogens. These substances are produced by burning any carbon-based fuel. Forest fires account for only 3 percent of the national POM total (Anonymous 1984). Risk of developing cancer due to POM from prescribed fire is estimated to be less than 1 in a million (Dost 1986).

### Nitrogen Oxides

At high concentrations, these toxic gases can affect the lungs. Prescribed fires emit only minor amounts by oxidation of fuel nitrogen. Most forest fuels contain less than 1 percent nitrogen, of which 20 percent is converted to nitrogen oxides when burned. Concentrations are not high enough to affect human health.

### Sulfur Oxides

Emissions of sulfur oxides are negligible because most forest fuels contain less than 0.2 percent sulfur. Emission factors for woody fuels are less than 0.4 lb/ton. Risk of adverse effects on human health is minimal.

### Photochemical Oxidants

Ozone can form in the upper layer of smoke plumes exposed to sunlight. Concentrations of up to 0.1 ppm have been reached in some plumes, usually in the first hour and within 2 miles downwind. Formation of photochemical oxidants by prescribed fire is a minor problem due to its intermittent occurrence.

## 2. Particulate Matter

Particulate matter, a complex mixture of solid and liquid particles, makes up the visible smoke seen in all fires. Particles 0.3-0.8 micron in diameter absorb and scatter

light most efficiently. Those less than 10 microns in diameter can be inhaled. Those less than 2.5 microns in diameter can be breathed into the lungs. The average particle diameter in forest fire smoke is 0.1-0.3 micron; 90 percent of particles are less than 2.5 microns and nearly all are less than 5 microns (McMahon 1983; Sandberg and Ward 1981; Sandberg and others 1979; Van Lear and Johnson 1983).

Effects of particulates on air quality are analyzed here in 3 phases. Local effects are those felt near the burn. General effects are those felt over an area downwind from the burn. Regional effects are the cumulative effects of particulate emissions over the whole Coastal Plain/Piedmont.

#### Air Quality Standards

EPA has developed air quality standards for particulates to protect public health from respiratory damage and public welfare from impaired visibility and transportation hazards. The new PM<sub>10</sub> standard applies to particulates less than 10 microns in diameter. It is exceeded if PM<sub>10</sub> concentrations exceed an average of 150 micrograms per cubic meter (ug/m<sup>3</sup>) for more than one 24-hour period per year, or an average of 50 ug/m<sup>3</sup> for an entire year (Stonefield 1987).

In addition to these general air quality standards, the Clean Air Act mandates special protection for visibility in Class I areas. There are 5 Class I areas in the Coastal Plain/Piedmont (table III-11). The basic strategy is to limit the total effect from all sources to less than a specified increase above a chosen baseline concentration. EPA may soon develop a PM<sub>2.5</sub> standard, for particulates less than 2.5 microns in diameter, which may have more impact on preserving visibility in Class I areas (Stonefield 1987).

In general, the states have responsibility for monitoring and enforcing air quality standards. National forests must comply with state regulations as well as our own smoke management guidelines.

#### Local Effects

In the South, the major effects of smoke on air quality are visibility reduction and respiratory impairment near the fire, especially on highways, at airports, and in populated areas. Particulate concentrations may meet the 24-hour standard of 150 ug/m<sup>3</sup> but exceed it by 10-fold or more for short periods. Personal exposure to such effects should occur only once every few years at most. This phenomenon is widely recognized, and research efforts have been organized to help control any temporary problems it might cause.

During flaming, smoke rises in a smoke plume. During smoldering, heat release is not enough to sustain plume rise so smoke stays near the ground. Ground smoke may worsen during inversions or in stable night air when rising humidity can cause a smoke-fog mixture to form. This



problem can be especially acute in river valleys. Use of smoke management guidelines mitigates impacts by enhancing flaming, reducing smoldering, and burning during atmospheric conditions that favor smoke dispersion (Lavdas 1986; McMahon 1983; Paul, Lavdas, and Wells 1987; Petersen and Lavdas 1986; National Wildfire Coordinating Group 1985).

Flaming is enhanced by using backing and flanking fires, which move slowly enough to preheat fuels and create a more uniform flame zone to consume gases. Smoldering is reduced by burning when large fuels are moist and unavailable and small fuels are dry, by broadcast burning slash rather than in piles (or at least keeping soil out of piles), and by promptly mopping up after the burn (McMahon 1983; National Wildfire Coordinating Group 1985; Pyne 1984; Sandberg and Ward 1981).

A slightly unstable atmosphere favors smoke dispersion. Such conditions are often characterized by good visibility, cumulus clouds, clear days, steady winds, and low to moderate humidity. Burning during downslope winds or high humidities should generally be avoided (Paul, Lavdas, and Wells 1987; National Wildfire Coordinating Group 1985).

#### General Effects

Smoke can impair general air quality in sensitive areas downwind from extensive burning. Use of smoke management guidelines mitigates impacts by reducing smoke emissions and burning during atmospheric conditions that favor smoke dispersion (Lavdas 1986; Petersen and Lavdas 1986; Sandberg 1983; USDA Forest Service 1976). Following is a discussion of smoke emission and dispersion principles.

SMOKE EMISSIONS are a product of emission factor (pounds of particulates produced per ton of fuel consumed) and amount of fuel consumed. Emissions are reduced by increasing combustion efficiency, which is highest during flaming and when small fuels are homogeneous, loose, and dry. Backing and flanking fires produce one-third of the smoke that head fires do. Mass-igniting slash burns, which reduces buildup time to flaming, can reduce emissions of a fire under ideal conditions by up to 25 percent. Broadcast burning slash rather than in piles (or at least keeping soil out of piles) greatly reduces smoldering (Sandberg 1983; Sandberg and Ward 1981; Sandberg and others 1979).

Emissions are also reduced by limiting fuel consumption. Slash burning when duff and large fuels are moist and unavailable limits smoldering and can reduce emissions of a fire under ideal conditions by up to 50 percent. This strategy is accomplished by scheduling slash burns soon after a soaking (0.5 inch or more) rain. Emissions from smoldering are also reduced by promptly mopping up after a burn (National Wildfire Coordinating Group 1985; Sandberg 1983, 1985; Sandberg and Ward 1981).

ATMOSPHERIC DISPERSION can lessen general effects through two smoke management strategies. "Avoidance" uses wind direction to send smoke away from sensitive areas. "Dilution" uses favorable weather conditions to reduce concentrations of smoke in sensitive areas downwind (Sandberg 1983).



Avoidance is most appropriate for reducing impacts to nearby areas by sending smoke away from them. To be successful, variations in wind direction over time and space must be considered. Because predicting wind direction is difficult for more than 24 hours, during light winds, and at night, avoidance is not usually appropriate for long-duration fires or fires that smolder into the evening.

Dilution relies on mixing smoke with clean air vertically and horizontally. Atmospheric stability, mixing height, and transport windspeed govern this process (National Wildfire Coordinating Group 1985; Pyne 1984; USDA Forest Service 1976).

Atmospheric stability affects rate of smoke dispersion. An unstable atmosphere is turbulent and rapidly mixes smoke. Slight instability usually provides adequate smoke dispersion but maintains a steady enough wind for good fire control. A neutral atmosphere may provide adequate dispersion, depending on other atmospheric factors.

Mixing height also affects rate of smoke dispersion. It is the vertical extent of unstable air, capped by an inversion or windshear layer, that allows vertical spread of a smoke plume through convection and turbulence. High mixing heights mean large volumes of air may be available for smoke dispersion. To provide adequate dispersion, mixing heights

should exceed 1,600 feet. Lower mixing heights are most common under low inversions and windshear layers, under stagnant high pressure systems, and on the cold air side of warm, stationary, or weak cold fronts. On generally clear nights with light winds when surface temperature inversions form, there is no mixing height and smoke is trapped near the ground and spreads very slowly.

Transport windspeed is the average windspeed in the layer of air likely to contain smoke. Adequate smoke dispersion requires a transport windspeed of at least 9 mph.

Combinations of atmospheric stability, mixing height, and transport windspeed needed for good smoke dispersion are most common between high and low pressure systems and behind vigorous cold fronts. The combined effects of atmospheric stability, mixing height, and transport windspeed on smoke dispersion have been expressed in a numerical rating called the "dispersion index" (Lavdas 1986).

#### Regional Effects

Regional effects on air quality are analyzed as the cumulative smoke emissions of all prescribed fires and wildfires on all lands in the Coastal Plain/Piedmont. Prescribed fire accounts for 17 percent of emissions from wildland fires in the South (Sandberg and others 1979). Even in alternative H, prescribed fires on national forests total 523,000 acres per year, only 10 percent of all prescribed fire acres in the area. National forest prescribed fires should thus account for less than 2 percent of smoke emissions from wildland fires ( $0.17 \times 0.10$ ) and have insignificant effects on regional air quality.

Other regional and global concerns are acid deposition, the greenhouse effect, and ozone impacts. Prescribed fires emit relatively minor amounts of organic acids, and nitrogen and sulfur oxides to the atmosphere, so their impact on acid deposition is negligible. They also release calcium and magnesium to air and soil, so they may actually reduce acid deposition locally (appendix B).

The greenhouse effect depends on the balance between global outputs of oxygen and carbon dioxide. The ozone layer is affected by global outputs of ozone-depleting compounds that reach the upper atmosphere. Wildland fires emit large amounts of carbon dioxide and smaller amounts of other "greenhouse" gases. They also emit compounds that can act as precursors for both ozone production and depletion. But forestry prescribed fires emit tiny amounts of such gases compared to other forms of biomass burning. All prescribed fires in all temperate forests of the world are estimated to account for only 0.1-0.4 percent of the global biomass burned annually (Seiler and Crutzen 1980).



### 3. Emission Estimates

Effects of the alternatives on air quality are analyzed by estimating total smoke emissions from prescribed fires and wildfires on national forests. Emissions are a product of emission factors, fuel loads, and acres burned in each of four major fuel groups:

a. **Grass**--national grasslands in Texas (38,000 acres); and pine-grass fuel types in south Alabama, southeast Mississippi, and southwest Louisiana (563,000 acres).

b. **Heavy brush**--pine/palmetto-gallberry, sand pine, and pond pine fuel types in Florida and along Mississippi and North Carolina coasts (1,362,000 acres).

c. **Hardwood**--Mississippi Valley (60,000 acres).

d. **Light brush**--Piedmont and rest of Coastal Plain (2,590,000 acres).

Emission factors vary by fuel consumed and combustion mode. Available fuels include grass in grass burns, plus litter and brush in underburns, plus tree limbs and foliage in slash burns and wildfires. Smoldering increases emission factors, which are typically 15 lb/ton for grass burns, 35 lb/ton for heavy brush underburns, 75 lb/ton for light brush underburns and slash burns, and 100 lb/ton for forest wildfires (McMahon 1983; Sandberg 1983; USDA Forest Service 1976; Ward 1983).

Available fuel load depends on fuel type, buildup, arrangement, and moisture content. Typical available fuel loads for underburns are 3-4 tons/ac in grass and light brush fuels and 4-6 tons/ac in heavy brush fuels (Mutz and others 1985; Sackett 1975; USDA Forest Service 1976). Wildfires in underburned stands consume 1 ton more than underburns because they tend to burn under drier conditions. If underburns are excluded, available fuel for wildfires can eventually build up to 8-10 tons/ac in light brush fuels and 18-22 tons/ac in heavy brush fuels (USDA Forest Service 1976).

Underburns interrupt fuel buildups, slowing the spread and aiding the control of wildfires. Excluding underburns in heavy brush fuels may increase average acres burned by wildfire by up to 100-fold (Davis and Cooper 1963). In our analysis, increases are assumed to be a very conservative 10-fold in heavy brush fuels and 5-fold in light brush fuels.

In each alternative, the acres burned by prescribed fire and wildfire are multiplied by the emission factors and fuel loads discussed above to estimate total smoke emissions from each fuel group. Acres burned by prescribed fire and wildfire are assumed to be distributed among the fuel groups as at present. See section N (Summary of Impacts by Alternatives) for smoke emission estimates.

## **I. WILDFIRE**

Periodic fires have played an important role in the formation and maintenance of Coastal Plain/Piedmont ecosystems. Coastal Plain pine forests are naturally fire-dependent. Prescribed fire can affect the occurrence and spread of wildfires.

### **1. Escaped Prescribed Fires**

Prescribed fires can become wildfires when they accidentally escape their boundaries and burn adjacent areas. These effects are mitigated by burning under fuel and weather conditions that promote control of fire spread. In general, escaped prescribed fires are quickly controlled, so their effects are minimal.

### **2. Fuel Reduction**

Underburns slow the spread and aid the control of wildfires by interrupting fuel buildup. When underburns are excluded, fire hazard increases progressively as litter accumulates, flammable understory shrubs increase in size, and needle drape develops, providing a pathway for surface fire to reach tree crowns (Wade 1983).

Unless reduced by underburns, fuels build up beneath pine stands until an equilibrium is reached between accumulation and decomposition (Wade 1983). Litter fuels reach equilibrium in 5-10 years (Sackett 1975), but time to total fuel equilibrium varies with latitude from about 20 years in north Florida to more than 25 years in Georgia and South Carolina (Wade 1983).

Available fuels in underburned stands amount to 3-6 tons per acre (USDA Forest Service 1976). If underburns are excluded, available fuels for wildfires can build to 8-10 tons per acre in light brush fuels and 18-22 tons per acre in heavy brush fuels (Martin and others 1979; USDA Forest Service 1976). Hazards are highest in palmetto-gallberry understories, which are very flammable and can grow to six feet, forming an effective "ladder" to the canopy (USDA Forest Service 1976).

Underburns done in cycles longer than 5 years in the Coastal Plain and 7 years in the Piedmont can damage the overstory and can be harder to control (Sackett 1975). Excluding underburns in heavy brush may increase average acres burned by wildfire up to 100-fold (Davis and Cooper 1963). In this analysis, increases are assumed to be a very conservative 10-fold in heavy brush fuels and 5-fold in light brush fuels. Over time, increased recreation use of national forests should increase risk of wildfire occurrence.

Prescribed fires also decrease wildfire hazard on adjacent lands. Excluding underburns increases spread of wildfire from national forests to these lands. Over time, increased urbanization should increase wildfire hazard to people and property.

## J. ROW CORRIDORS

The type, species, and amount of vegetation affect treatments needed to maintain safety and integrity of the facility occupying a right-of-way. Insufficient vegetation management reduces safety along roads, trails, and utility lines; creates power outages; and increases facility maintenance costs, wildfire potential, and investment loss. Excessive vegetation manipulation or improper timing of treatments can cause accelerated soil erosion, degraded aesthetics, recreation value loss, water pollution, and unnecessary costs.

Improved visibility along roads and trails and adequate access to utility lines are created by managing vegetation on rights-of-way. Investments in facilities are maintained and transportation networks are kept open. Maintaining vegetation on utility lines allows for uninterrupted electricity flows and efficient checking for gas leaks.

Prudent vegetation management on rights-of-way provides for visual quality, wildlife habitat, and recreation potential. Practices should include selecting target vegetation carefully; changing vegetation to conform to acceptable heights and widths; and locating corridors to minimize vegetation treatments. Placing compatible facilities within one corridor reduces acres needing treatment. Treatments are done to meet legal and safety requirements specified in laws, regulations, and special-use permits.

Effects on rights-of-way are identical to those identified in other sections of this chapter. These effects occur repeatedly and may differ only in timing, intensity, and frequency.

Prescribed fire is not often used, unless included within adjacent prescribed burns. Burns are limited because of the narrow width of rights-of-way and potential hazard to power poles or from gas leaks along pipelines.

Corridor maintenance decreases woody vegetation and increases shrubs, herbs, wildflowers, and grasses. Vegetation browning occurs on treated areas. Over time, multiple treatments give the corridor an appearance of permanence. This is primarily a visual effect.

## K. VISUAL QUALITY

Of all landscape elements, vegetation is the most significant and readily manipulated visual feature. Treatment intensity and timing affect the degree of impact on visual quality. A favorable climate and vegetation variety allow vegetation to recover quickly after most treatments. In assessing effects of treatments in each alternative, it is assumed that management requirements and mitigation measures (chapter II) are employed, and that



visual quality objectives (VQO) for treatment areas may be met except for alternatives A and H. Variables that affect scenic quality are treatment type, number of acres treated, slope, and duration of effect.

#### **1. Effects of Prescribed Fire**



Prescribed fire temporarily reduces understory vegetation and can maintain open forested conditions with more opportunity for views and vistas. Reduction of underbrush creates better pedestrian access. Periodic fire also promotes numerous flowering plants.

Light burns create a charred appearance on tree trunks and lower limbs that lasts 3 to 4 months. With more intense burns and in hot spots, more of the tree is charred and the effect can last 3-5 years or more. Smoke accumulations on relatively calm days reduce visibility in downwind areas. Windier days disperse smoke faster and keep visibility higher, but may affect larger areas.

Repeated treatments by fire in the same area can reduce understory species and maintain side spacing between trees. On rights-of-way variety changes from tall trees to shrubs, herbs, and grasses; however, the number of plants increases considerably. The vegetation mix remains dynamic and fluctuates with treatments. These changes create a variety of wildflowers, flowering shrubs, grasses, and other plants (Bramble and Byrnes 1982).

#### **2. Effects of Mechanical Methods**

Mechanical methods can expose soils and generally reduce vegetation to ground level or less than 3 feet high. Considerable seasonal browning occurs and broken stems create an unsightly landscape. Raking and piling leave debris that may be visible 3 to 4 years before being obscured by new growth, unless the windrows or piles are burned. Mechanical treatments reduce shading vegetation and allow more wildflowers and other sun-tolerant plants to come into the area until trees and shrubs shade or crowd them out.

#### **3. Effects of Manual Methods**

Manual treatments leave browned slash and a graying appearance for a season to a year. Regrowth and residual vegetation obscure the effect within a few months. Canopy heights are reduced, but species variety is maintained.

#### **4. Effects of Herbicides**

Herbicide treatments reduce variety by eliminating target species, but the space is usually filled quickly by lower-growing shrubs or herbs. Herbicides also create a browning and then a graying that can last from a season to several years depending on the treated vegetation's height and the herbicide's persistence. Frequent treatments as on rights-of-way have less lasting visual effects. Broadcast applications create a stronger visual effect than more selective ones, which create irregular or spot patterns of brown and gray and cover less total area.

## **5. Effects of Biological Methods**

The heavy grazing required for pine release exposes bare and compacted soil. Adverse visual effects are limited to the foreground and middle ground and, due to the few acres involved, are localized and rare.

## **L. CULTURAL RESOURCES**

Cultural resources are affected by activities that cause soil disturbance, particularly mechanical treatments. Mechanical tools differ in their potential to disturb archaeological sites through soil penetration. Potential impact is low for mowing, shearing, and piling where disturbance is confined to the surface; moderate for chopping, scarifying, raking, and light disking where disturbance seldom exceeds 4 inches in depth; and high for bedding, heavy diskings, and heavy ripping where disturbance can exceed 12 inches in depth. Sites in floodplains are usually less prone to disturbance than sites on ridges and sideslopes because they are buried under layers of sediment deposited over many years. Effects from prescribed fire are generally limited to resources on or above ground such as buildings.

Vegetation management should not be viewed as a single, isolated activity, but rather as one element of a broader resource management program. Roads, trails, and utility lines may already have been built and timber may have been harvested. These activities can cause substantial soil disturbance without vegetation management.

Each cultural resource is a piece of a puzzle that tells us about earlier societies. Loss or damage of one artifact may limit our understanding of earlier societies, but this loss may not always be critical. As more artifacts are lost, however, interpretation becomes increasingly difficult. Related to this cumulative loss is the fact that cultural resources are more protected on Federal than other lands. Loss or damage of cultural resources on other lands could increase the importance of such resources on Federal lands.

## **M. SOCIOECONOMIC CONDITIONS**

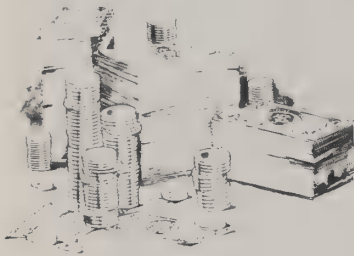
All user groups including workers, neighbors, and visitors identified in chapter III are affected by vegetation management. These effects, however, are dwarfed by the magnitude of other national or even global trends. Effects are related to treatment location, size, method, and tool.

### **1. Effects on User Expectations**

User expectations cover the range from primitive to rural (chapter III). Vegetation management enhances the ability to meet some expectations and reduces the ability to meet others. Effects on user expectations range from no treatments to low disturbance treatments for a primitive setting of solitude and challenge, to high disturbance treatments for a rural setting of social contact and comfort.

Treatments may change the nature and degree of social conflict related to attitudes, beliefs, and values about the vegetation management program, or even general management of forest resources. Treatments used over long periods or large areas may alter expectations. Expectations are related to the kind and degree of social conflict and acceptance level of the program.

## 2. Effects on Employment



Despite greater influences from regional or national trends, rural communities depend heavily on agriculture and forestry occupations for employment. Employment provided relates to labor intensity of the practices used (Watson, Straka, and Bullard 1987). In the Coastal Plain/Piedmont, the average labor component (including supervision and overhead) of each method's total cost is:

<u>*Method</u>	<u>Percent Labor</u>
Mechanical	39
Prescribed Fire (Ground)	67
Prescribed Fire (Aerial)	49
Herbicide (Ground)	26
Herbicide (Aerial)	17
Manual	92

\*Biological data are not included in this study, but herd management (labor) represents a small component.

## 3. Effects on Civil Rights

In every alternative, effects on civil rights, including those of minorities and women, are negligible and unplanned. Analysis of possible effects occurs in the site-specific environmental analysis or during project design. The following topics are of concern:

- Risks to worker health and safety because racial and cultural minority groups may represent a large fraction of this work force;
- Employment opportunities and representation in the work force for minorities.

## 4. Effects on Outputs and Costs

Some outputs are generated at the expense of others, and output levels may change with intensity of treatment. Costs for conducting vegetation management also vary. Some treatments are long-lasting while others must be repeated. Some require little labor or equipment and others require much.

Production of outputs in many cases requires vegetation management. Each multiple use including forage, recreation, water, wildlife, and wood is affected. Conversely, lack of treatment is sometimes essential for these outputs. For



example, vegetation management is done to retain or improve vistas for road tours, but little is done in a primitive setting where a closeness to nature is desired. Each is a recreation output and each requires different treatment.

Information on activity cost, acres, method of treatment, and purpose was collected from all Coastal Plain/Piedmont forests and from Watson, Straka, and Bullard (1987) for work done during fiscal years 1986 and 1987. One ranger district in Florida provided 1985 and 1986 data. These figures represent an expenditure of \$11.9 million (labor, materials, handling, equipment, supervision) on 802,138 acres. Average costs by method and tool are shown in table IV-18. Average costs by activity are:

#### Pine Management

<u>Activity</u>	<u>Average Cost/Acre</u>
Site Preparation	\$61.71
Timber Stand Improvement	21.75
Wildlife Habitat Improvement	5.56
Wildlife Openings Maintenance	65.23
Corridor Maintenance	40.80
Range Forage Maintenance	3.79
Fuels Treatment	3.90

#### Hardwood Management\*

<u>Activity**</u>	<u>Average Cost/Acre</u>
Site Preparation	\$76.33
Timber Stand Improvement	77.76

\*Represents less than 1 percent of sample

\*\*Data not available on other purposes, assumed to be somewhat higher than in pine management.

Vegetation management may change the amount of money passing through the economy, particularly in the form of wages and 25-percent returns to county governments. It may also change indirect costs and opportunity costs. For instance, action or lack of action at the right time and place results in later costs or loss of subsequent benefits. Local or area economics and social structures adjust over the long term to reflect labor force needs, services, and money flowing through the community. Both supply and demand tend to adjust toward equilibrium.

Table IV-18.--Vegetation management costs per acre by method, Coastal Plain/Piedmont

Vegetation Management Method	-----Per Acre Cost-----		Average Cost/Acre
	Coastal Plain	Piedmont	
<u>Herbicide</u>			68.95
Aerial tools			
Helicopter	77.29*		
Mechanical ground tools			
Boom sprayers	71.88	95.30	
Granular spreader	71.76	95.00	
Hand tools			
Backpack sprayers	70.87	84.20	
Spotgun	78.58	87.65	
Hypo-hatchet	41.59	60.01	
Injectors	54.45	58.91	
Hack & Squirt	88.00	101.43	
Backpack sprayers/injectors	61.50*	70.64	
Injectors/hypo-hatchets	50.00	57.50	
<u>Manual</u>			69.95
Power tools	73.64	88.03	
Chainsaws	59.51	66.83	
Brushcutters	89.86	103.34	
Brushcutters/chainsaws	73.64	88.03	
Hand tools			
Axe	74.60	62.50	
Brushhook	77.57	89.20	
Brushcutters/handtools	90.52	104.10	
Brushcutters/brushhook	72.10	82.92	
Brushhook/chainsaw	71.21	81.89	
<u>Mechanical</u>			75.49
Chopping tools	53.62	75.40	
Crushing tools	94.00	108.00	
Scarifying tools	75.49	86.81	
Shearing tools	57.57	66.00	
Piling, raking tools	87.09	100.00	
Disking tools	54.34	62.49	
Bedding tools	42.12	48.50	
Mowing tools	43.70	50.00	
Chopping/shearing/piling/raking	158.60	182.39	
Chopping/shearing/bedding	122.60	140.99	
Chopping/piling, raking/disking	156.04	179.45	
Chopping/disking	85.43	98.24	
Chopping/disking/bedding	113.51	130.54	
Chopping/bedding	76.60	88.09	
Shearing/crushing	121.30	139.50	
Shearing/piling, raking	129.87	149.35	
Shearing/piling, raking/chopping	158.60	182.39	
Shearing/piling, raking/disking	159.20	183.08	
Shearing/piling, raking/bedding	149.40	171.81	
Shearing/piling, raking/mowing	150.70	173.30	
Shearing/disking/bedding	124.88	143.61	
Shearing/bedding	79.80	91.77	
Piling, raking/disking	113.10	130.06	
<u>Prescribed Fire</u>			4.69
Aerial ignition devices	3.58	11.87	
Helitorch	5.66		
Drip, drag torches	4.64	10.29	

Biological - No data

\*Watson, Straka, and Bullard (1987)

## **N. SUMMARY OF IMPACTS BY ALTERNATIVES**

This section displays overall environmental effects of each alternative. A capsule of the alternative's program is followed by an element-by-element discussion of environmental effects. This section forms the basis for the comparison of alternatives in sections II.G and II.H.

### **Alternative A**

**This is the "no action" alternative. Vegetation management is not done. Existing vegetation is allowed to grow without manipulation.**

#### **Human Health and Safety**

Neither workers nor the public are exposed to vegetation management tools. Indirect health and safety risks increase over time as vegetation growth encroaches on corridors and builds up fuel loads.

Failure to maintain roadways creates high risks for human health and safety. Roadside vegetation grows uncontrolled and obstructs vision, making roads hazardous within 3-5 years. Road surfaces are also damaged. Risk of power outage results when vegetation grows in rights-of-way and contacts transmission wires.

Exclusion of prescribed fire permits hazardous fuels to accumulate. Wildfire hazard with associated risk to human health and safety is high. Risks of wildfire-related injury increase over time at different rates based on fuel type, age, and other ecological factors.

#### **Vegetation**

Succession following timber harvest proceeds uninterrupted except for natural occurrences such as wildfires, floods, tornadoes, and hurricanes. Complete regeneration failures, as well as marginal survival and loss of growth and form, occur for both natural and planted pine and hardwood species on harvested areas with vigorous competing vegetation. Herbaceous species gradually decline. Shade-tolerant woody species gradually replace shade-intolerant species in the midstory and overstory.

Wildfires occurring during dry weather in accumulations of hazardous fuels are of high intensity, causing significant injury and mortality to vegetation. Greater mortality of woody vegetation occurs during the growing season.

Noxious weeds grow unchecked. Forest visitors are exposed to more weeds resulting in a higher proportion of visitors suffering minor health problems than in alternatives where noxious weeds are controlled.

#### **Wildlife and Aquatic Animals**

Prescribed fire and other treatments are unavailable for improving habitat for any species. Fire-dependent species such as quail decline. Because intermediate treatments are not done, regeneration areas rapidly lose their value for species like deer as forage and browse production declines.



Increased wildfires create habitat for early successional species but destroy habitat for mid to late successional species such as brown-headed nuthatch (Sitta pusilla) and pileated woodpecker (Hylatomus pileatus). Species such as grey squirrel benefit from hard-mast production, but many species are affected adversely by low soft-mast and forage production.

Wildlife openings and rights-of-way lose their value as feeding and nesting areas for species like turkey and rabbits as woody vegetation encroaches. Since no management is done, few downed logs are created for sunning sites for reptiles or cover for amphibians, and few snags are created for raptors or cavity-nesting birds.

Threatened,  
Endangered,  
Proposed, and  
Sensitive Species

Lack of vegetation management, particularly prescribed fire, prevents management of habitat for any species. Habitat is improved for some species but destroyed for others by high intensity wildfires. Many species, especially fire-dependent species like the gopher tortoise and large-flowered bonamia, decline. Although extinction is improbable as long as populations exist on State or private lands, recovery becomes unlikely as habitat suitability declines.

Soil

Lack of underburns allows soil productivity in pine forests to deteriorate naturally through leaching and weathering. Because this process is so slow, effects are negligible.

Lack of underburns in all fuel types allows wildfire hazard to increase through progressive fuel buildup. Wildfires are estimated to burn about 7.7 times the present number of acres. Some of these acres are severely burned, resulting in impaired soil productivity.

Water

No treatment effects on water quantity or quality occur. The increase in severe wildfires mentioned above, however, increases stormflows and sediment yields in some areas.

Wildfire and  
Air Quality

Because prescribed fire is not used, wildfires are estimated to increase to at least 92,000 acres per year and are more intense. Annual smoke emissions from national forest lands are estimated to average 62,500 tons per year, all from wildfires.

ROW Corridors

Natural conditions prevail with climax species becoming dominant. Utility lines become non-functional with power outages, roads and railroads interrupted, and trails closed. Unplanned fires are expected along railroads, and facility investments are lost.

Visual Quality	Lack of treatment allows vegetation to encroach on views and vistas. Open, parklike areas eventually disappear with encroachment of midstory and understory vegetation. Wildfires are more intense, often crowning, which increases mortality and creates a negative visual effect.
Cultural Resources	Risk of damage to cultural resources is low because no treatments are allowed. There is an increased risk of damage from wildfires.
Socioeconomic Conditions	Alternative A directly benefits those who enjoy a primitive forest setting, and negatively affects those who enjoy more rural settings. Employment opportunities and direct costs are lowest. Indirect and opportunity costs are highest. Effects on outputs vary extensively, but managed outputs generally decline while unmanaged outputs increase over current levels.
<b>Alternative B</b>	<b>Vegetation management is done only to protect forest and grassland resources and public health and safety. Minimum risk herbicides are applied by hand. Low disturbance mechanical tools and low intensity prescribed fire are used. Acres treated per year total 130,500.</b>
Human Health and Safety	<p>Risk to workers is minimal, and exposure is limited by the number of acres treated. Individual workers may be at slight risk because backpack sprayers (the method with the lowest margin of safety for workers) are used.</p> <p>Slight risk to workers and visitors results from uncontrolled growth of noxious weeds. Resulting injuries are expected to be minor.</p> <p>Reduced worker exposure to vegetation management tools means that human health dangers are minimized over a person's career. Small number of acres treated reduces risk to individual workers. Wildfire related injuries are less than alternative A but greater than other alternatives. Minimal use of herbicides ensures that all of the chemical is eliminated from the worker's body between exposures. Public exposure is low, and negative effects are negligible.</p>
Vegetation	<p>Herbicide effects are limited. Selective application only is used on 3,500 acres, resulting in minimal loss of non-target plants. Treatment is primarily to control woody overstory species and favor low woody and herbaceous species.</p> <p>Prescribed burning at a 5-year cycle in the Coastal Plain marginally controls hazardous fuels buildup. Prescribed burning outside of hazardous areas does not occur. Fuels buildup in those areas continues unchecked but reaches equilibrium in 10 to 20 years. During dry weather, some vegetation injury and mortality occur in areas not normally considered as having hazardous fuels.</p>

Succession following timber harvest proceeds uninterrupted except for natural occurrences such as wildfires, floods, tornadoes, and hurricanes. Complete regeneration failures, as well as marginal survival and loss of growth and form, occur for both natural and planted pine and hardwood species on harvested areas with vigorous competing vegetation. Herbaceous species gradually decline. Shade-tolerant woody species gradually replace shade-intolerant species in the midstory and overstory.

Wildlife and  
Aquatic Animals

Effects are similar to alternative A, but fire-dependent species benefit slightly more since some prescribed burning occurs. Maintained rights-of-way produce habitat and some "edge" for species like rabbits.

Threatened,  
Engangered,  
Proposed, and  
Sensitive Species

Because of limited management, known populations are maintained but recovery is not likely.

Soil

Underburns occur only in heavy brush fuel types. Soil productivity in other pine fuel types deteriorates naturally through leaching and weathering. Because this process is so slow, effects are negligible.

Lack of underburns in all but heavy brush fuels allows wildfire hazard to increase through progressive fuel buildup. Wildfires are estimated to burn about 4.3 times the present number of acres. Some acres are severely burned, resulting in impaired soil productivity.

Underburns occur every 5 years generally and 3 years in habitat for threatened and endangered species, only in the dormant season. Slash burns, piling, raking, and biological methods are not used. Underburns pose low risk to productivity of poor soils only, on 137,200 acres over time.

Water

Site preparation is not done, so nearly all sediment is caused by broadcast herbicide use on a projected 2,741 acres per year of roadsides and utility lines. Treatments produce about 20 tons of sediment per year. Treatment effects on stormflows and herbicide concentrations are minimal. The increase in severe wildfires mentioned above, however, increases stormflows and sediment yields in some areas.

Wildfire and  
Air Quality

Underburns are projected to occur on 113,573 acres per year. Wildfires are estimated to increase to at least 52,000 acres per year and are more intense. Annual smoke emissions from national forest lands are estimated to average 11,900 tons from prescribed fire and 24,900 tons from wildfire, for a total of 36,800 tons.



ROW Corridors	Maintenance is performed to protect investments and prevent safety hazards. Understory vegetation is normally unmanaged with an uneven overstory having taller woody plants that reach maximum height under powerlines and maximum widths along road rights-of-way. Additional manpower is needed to accomplish these treatments. The small acreages assigned to mechanical and manual treatments may be insufficient to meet safety and investment protection levels.
Visual Quality	Visual impacts are minimal and activities are performed to meet established visual quality objectives.
Cultural Resources	Alternative B has the lowest risk because fire protection is allowed and mechanical treatments do not disturb soils.
Socioeconomic Conditions	Alternative B favors primitive expectations and outputs which require little management as in alternative A, while opportunity and indirect costs are diminished and employment opportunities increase slightly (far below current). Total cost of the program is \$2.03 million and per-acre treatment cost is \$15.54.
<b>Alternative C</b>	<b>Vegetation management is restricted to treatments that achieve minimum resource objectives. Minimum risk herbicides are applied by hand. Low disturbance mechanical tools and low intensity prescribed fire are used. Acres treated per year total 414,500.</b>
Human Health and Safety	<p>Herbicides applied exclusively by manual methods cause a somewhat greater health risk to individual workers than at present. Margins of safety for all chemicals are lowest for this type of application. Low level of herbicide usage, however, should cause low total worker and public exposure to herbicide.</p> <p>Low level of herbicide use in this alternative means that other methods are used to accomplish vegetation management goals. Other methods have a higher rate of accident occurrence than herbicides, so a relatively high rate of injury is expected. No risk from other methods is expected for the public.</p> <p>Distributions of accidents by cause and frequency are not expected to change from present. About 20 percent less acreage is treated than at present, which results in fewer total accidents.</p>
Vegetation	The effects of herbicides on vegetation are similar to "B" but occur on 17,000 acres. Effect on non-target vegetation continues to be lower than at present due to the selectivity of the tools and the lesser number of acres treated.

Prescribed burning at a 5-year cycle (Coastal Plain) and a 7-year cycle (Piedmont) marginally controls the buildup of hazardous fuels. Low-intensity growing and dormant season burns at these cycles produce a mix of woody and herbaceous species. Dormant season burns predominate producing a greater number of woody species in the understory and midstory. Herbaceous species decrease in number. Range burns on a 5-year cycle marginally maintain range forage species. Some preferred forage plants decline.

Mechanical tools causing only low soil disturbance are used. Herbaceous species initially increase, then after 3 years begin to decline. Woody species initially decline, but most recover within 5 years. Mortality of woody species due to uprooting is very low.

Moderate amounts of manual methods are used. Repeated treatments must occur on sites with high numbers of competing stems in order to successfully release or precommercially thin pine and hardwood seedlings or saplings.

Areas where grazing is used as a biological method have some pine and hardwood seedling losses from plant injury or mortality. Heavy grazing intensities cause shifts in herbaceous species composition.

#### Wildlife and Aquatic Animals

The 5-7 year prescribed burning cycle is more beneficial for deer and turkey than limited or no burning, but allows browse, forage, and soft-mast to decline. Species like meadowlarks, which use very early successional stage habitat, have less habitat than when more intensive site preparation methods are used. Species such as grey squirrel benefit from selective herbicide treatments which are less detrimental to hard- and soft-mast producers than broadcast treatments. Snags are created for raptors and cavity nesters. Downed logs are provided for reptiles and amphibians.

#### Threatened, Endangered, Proposed, and Sensitive Species

All vegetation management methods are available for habitat management. Mitigation measures assure adequate inventory of threatened, endangered, proposed, and sensitive species and protect populations from adverse effects of vegetation management. Recovery is likely if impacts from external factors are controlled.

#### Soil

Underburns occur every 5 years in the Coastal Plain, 7 years in the Piedmont, and 2 years in habitat for threatened and endangered species. Use of growing season burns is minor. Slash burns compose 25 percent of site preparation acres and are estimated to be 70 percent light and 30 percent moderate. Piling and raking are not used. Use of biological methods is minor.

In general, 2-year underburns pose medium risk to soil productivity. Other underburns and moderate slash burns pose low risk to poor soils only. Biological methods pose high risk from heavy grazing. Effects of all other tools are minimal. Over time, risk to soil productivity from vegetation management is estimated to be low on 237,500 acres and medium on 78,800 acres.

**Water**

Nearly all sediment is caused by non-manual site preparation and broadcast herbicide use on roadsides and utility lines (projected 33,675 and 4,058 acres per year, respectively). Treatment intensity is low, producing about 400 tons of sediment per year. Effects on stormflows and herbicide concentrations are minimal.

**Wildfire and  
Air Quality**

Slash burns are projected to occur on 8,862 acres per year, underburns on 346,072 acres per year, and wildfires on 15,000 acres per year. Annual smoke emissions from national forest lands are estimated to average 36,700 tons from prescribed fire and 4,400 tons from wildfire, for a total of 41,100 tons.

**ROW Corridors**

Maintenance is performed to protect investments and prevent safety hazards. Understory vegetation is normally unmanaged with an uneven overstory having taller woody plants that reach maximum height under powerlines and maximum widths along road rights-of-way. Additional manpower is needed to accomplish these treatments. The small acreages assigned to mechanical and manual treatments may be insufficient to meet safety and investment protection levels.

**Visual Quality**

Visual impacts are less than at present because fewer acres are treated. Visitors viewing treated areas see evidence of treatments, but degree of change should be visually acceptable when Retention and Partial Retention visual quality objectives are met.

**Cultural Resources**

More acres are treated by mechanical methods than in alternative B. Ripping is the only tool used that causes high risk to archaeological sites that may have been missed by field surveys. Other tools cause low to moderate disturbance. Risks are higher than in A or B but still in the low range.

**Socioeconomic  
Conditions**

Unmanaged outputs are emphasized, and managed outputs are at levels well below current. Indirect and opportunity costs are high. Employment opportunities are more favorable than alternative B but below current. Treatments result in settings favored by those nearer the primitive end of the expectations scale. Total cost is in the low range at \$5.97 million, but about three times that of alternative B. Per-acre costs are \$14.40, the lowest of any alternative.



## Alternative D

Herbicides are not used. Mechanical tools cause low to moderate disturbance. Prescribed fire is of low to moderate intensity. Acres treated per year total 553,500.

### Human Health and Safety

No use of herbicides in this alternative means that other methods are used to accomplish vegetation management goals. Other methods, especially manual, have a higher rate of accident occurrence, so a relatively high rate of worker injury is expected. Public perception of safety improves, but worker safety declines while public safety is not affected.

### Vegetation

Prescribed burning at a 4-year cycle (Coastal Plain) and 6-year cycle (Piedmont) adequately controls the buildup of hazardous fuels. Low to moderate intensity, growing and dormant season burns at these cycles produce a mix of woody and herbaceous mid- and understory species. Growing season burns, however, can be expected to produce a greater number and variety of herbaceous species. Range burns on a 3-year cycle sustain a mix of preferred range forage species consisting of native grasses, forbs, and legumes.

Mechanical tools causing low to moderate soil disturbance are used. Herbaceous species initially increase, then decline within 3 to 5 years, depending upon tool intensity. Woody species initially decline. Higher intensity tools or combinations (such as shearing and piling or bedding) produce a greater decline. Since no raking or heavy disking occurs, mortality of woody species through uprooting is very low. Woody species fully recover within 5 to 10 years following treatment.

Moderate amounts of manual methods are used. Repeated treatments must occur on sites with high numbers of competing stems in order to successfully release or precommercially thin pine and hardwood seedlings or saplings.

Areas using grazing as a biological method have some pine and hardwood seedling losses from plant injury and mortality. Heavy grazing intensities cause shifts in herbaceous species composition.

### Wildlife and Aquatic Animals

All methods except herbicides are available to manage for a broad range of wildlife species. High use of mechanical tools creates habitat for species like doves which use very early successional stage habitat. The 4-6 year prescribed burning cycle improves habitat for fire-dependent species and is generally favorable for species needing soft-mast, such as deer and turkey. Absence of broadcast herbicide treatments favors hard- and soft-mast producers used by many species. Mechanical site preparation leaves fewer snags than alternative C but creates more downed logs used by reptiles and amphibians, unless combined with slash burning.

Threatened,  
Endangered,  
Proposed, and  
Sensitive Species

All methods but herbicides are available for habitat management. Mitigation measures assure adequate inventory of threatened, endangered, proposed, and sensitive species and protect populations from adverse effects of vegetation management. Recovery is likely if impacts from external factors are controlled.



Soil

Underburns occur every 4 years in the Coastal Plain, 6 years in the Piedmont, and 2 years in habitat for threatened and endangered species. Use of growing season burns is significant. Slash burns compose 35 percent of site preparation acres and are estimated to be 50 percent light and 50 percent moderate. Piling composes 30 percent of site preparation acres, but raking is not used. Use of biological methods is low.

In general, 2-year underburns pose medium risk to soil productivity. Other underburns, moderate slash burns, and piling pose low risk to poor soils only, but growing season underburns increase risk where they are used. Biological methods pose high risk from overgrazing. Effects of all other tools are minimal. Over time, risk to soil productivity from vegetation management is estimated to be low on 313,400 acres and medium on 78,800 acres.

Water

Nearly all sediment is caused by non-manual site preparation on a projected 47,429 acres per year. Herbicides are not used, so their effects are nil. Treatment intensity is low to moderate, producing about 840 tons of sediment per year. Effects on stormflows are minimal.

Wildfire and  
Air Quality

Slash burns are projected to occur on 17,474 acres per year, underburns on 446,810 acres per year, and wildfires on 12,000 acres per year. Annual smoke emissions from national

forest lands are estimated to average 42,100 tons from prescribed fire and 3,100 tons from wildfire, for a total of 45,200 tons.

ROW Corridors

Without herbicide use, mechanical and manual methods increase on rights-of-way to maintain the facilities' structural integrity, meet safety requirements, and protect investments. Mechanical treatments replace herbicide treatments, which causes machinery and labor costs to increase. Because some areas might be inaccessible by mechanical methods, high cost-per-acre treatments or occasional power outages from vegetation reaching powerline conductors result.

Visual Quality

Visual impacts result mainly from prescribed fire and mechanical treatments. Visitors viewing the treated areas see significant vegetation disruption for 3 to 4 months after treatments. Treatments normally meet retention to modification visual quality objectives.

Cultural Resources

The high number of acres treated by mechanical methods increases risk of damage to cultural resources, but low to moderate disturbance tools except for ripping and bedding mitigate some of this risk.

Socioeconomic  
Conditions

Elimination of herbicides affects the level of social conflict. Those who favor primitive settings are adversely affected by an increased use of mechanical methods but aided by an increased use of hand methods over the current program. Total costs are \$8.76 million and per-acre costs are comparable to current costs at \$15.82.

Alternative B

**Manual methods and prescribed fire are the favored means of vegetation control. Minimum risk herbicides are applied by hand and machine. Mechanical tools cause low to moderate disturbance. Prescribed fire is of low to moderate intensity. Acres treated per year total 553,500.**

Human Health  
and Safety

Mix of herbicide application tools and restricted amount of herbicide treatment keep herbicide-related health risks low. Increased hand-tool work results in a high rate of accidental lacerations from chain saws and cutting tools.

Vegetation

Choice of herbicide and application method allows either selective or broadcast treatments of granular and liquid herbicides. The overall effect on vegetation is less than for either "C" or "F" primarily due to the reduced number of acres (11,500) treated. While risk to non-target vegetation is greater for broadcast treatments, low acreage of treatment keeps overall risk to non-target vegetation low.



Prescribed burning at a 4-year cycle (Coastal Plain) and 6-year cycle (Piedmont) adequately controls the buildup of hazardous fuels. Low to moderate intensity, growing and dormant season burns at these cycles produce a mix of woody and herbaceous mid- and understory species. Growing season burns, however, can be expected to produce a greater number and variety of herbaceous species. Range burns on a 3-year cycle sustain a mix of preferred range forage species consisting of native grasses, forbs, and legumes.

Mechanical tools causing low to moderate soil disturbance are used. Herbaceous species initially increase, then decline within 3 to 5 years, depending upon tool intensity. Woody species initially decline. Higher intensity tools or combinations (such as shearing and piling or bedding) produce a greater decline. Since no raking or heavy disking occurs, mortality of woody species through uprooting is very low. Woody species fully recover within 5 to 10 years following treatment.

High use of manual methods in more areas causes a substantial increase in the amount of repeated treatments on sites with high numbers of competing stems in order to successfully release or precommercially thin pine and hardwood seedlings or saplings.

Areas using grazing as a biological method have some pine and hardwood seedling losses from plant injury and mortality. Heavy grazing intensities cause shifts in herbaceous species composition.

#### Wildlife and Aquatic Animals

High use of manual and low use of mechanical tools should selectively favor hard- and soft-mast producing woody plants. Adverse effects on mast producers from herbicides are greater than in alternative D but less than in alternative C. Methods used create less habitat for species such as dove, which use very early successional stage habitat, than intensive mechanical tools. Fire-dependent species benefit from an extensive burning program on a 4-6 year cycle, which improves browse, forage, and soft mast production.

#### Threatened, Endangered, Proposed, and Sensitive Species

All methods are available for habitat management. Mitigation measures assure adequate inventory of threatened, endangered, proposed, and sensitive species and protect populations from adverse effects of vegetation management. Recovery is likely if impacts from external factors are controlled.

#### Soil

Underburns occur every 4 years in the Coastal Plain, 6 years in the Piedmont, and 2 years in habitat for threatened and endangered species. Use of growing season burns is significant. Slash burns compose 50 percent of site preparation acres and are estimated to be 50 percent

light and 50 percent moderate. Piling composes only 5 percent of site preparation acres, and raking is not used. Use of biological methods is moderate.

In general, 2-year underburns pose medium risk to soil productivity. Other underburns, moderate slash burns, and piling pose low risk to poor soils only, but growing season underburns increase risk where they are used. Biological methods pose high risk from heavy grazing. Effects of all other tools are minimal. Over time, risk to soil productivity from vegetation management is estimated to be low on 302,300 acres and medium on 78,800 acres.

Water

Nearly all sediment is caused by non-manual site preparation and broadcast herbicide use on roadsides and utility lines (projected 34,947 and 4,233 acres per year, respectively). Manual methods and prescribed fire are favored for site preparation, and low to moderate treatment intensity produces about 410 tons of sediment per year. Effects on stormflows and herbicide concentrations are minimal.

Wildfire and  
Air Quality

Slash burns are projected to occur on 24,962 acres per year, underburns on 447,567 acres per year, and wildfires on 12,000 acres per year. Annual smoke emissions from national forest lands are estimated to average 43,800 tons from prescribed fire and 3,100 tons from wildfire, for a total of 46,900 tons.

ROW Corridors

Treatment methods for effective control are available and target species are controlled. Species having desired height, width, and density are favored. Plant species are promoted to enhance wildlife habitat and food, provide recreation potential and aesthetic value, and reduce overall maintenance costs.

Visual Quality

Visual impacts result mainly from prescribed fire and mechanical treatments. Visitors viewing the treated areas see significant vegetation disruption for 3 to 4 months after treatments. Treatments normally meet retention to modification visual quality objectives.

Cultural Resources

Fewer acres treated mechanically, and use of tools causing low to moderate soil disturbance except for ripping and bedding, reduce risks from present.

Socioeconomic  
Conditions

This alternative has the highest potential for employment and favors primitive experiences somewhat more than present. Opportunity costs and indirect costs compare with alternative C. Total program costs are \$7.99 million, lower than current but higher than alternatives B and C. Per acre costs are \$14.43, comparable to alternative C.

**Alternative F**

This alternative continues present levels of treatment specified in the Forest Land and Resource Management Plans. Herbicides are applied by hand and machine. Mechanical tools cause low to high disturbance. Prescribed fire is of low to high intensity. Acres treated per year total 553,500.

**Human Health  
and Safety**

Typical herbicide use levels pose no health risk to the public. Workers are exposed to risk only when using 2,4-D, 2,4-DP, or tebuthiuron, and then only with certain application methods. At maximum use rates, several of the herbicides pose risks to workers and the public. About 12 vegetation management related injuries occur per year, and about half of them are serious.

**Vegetation**

The effects of herbicide treatments are similar to "E". Use of broadcast treatments on larger acreage increases potential for damage to non-target vegetation. Herbicides are used on 27,000 acres. Temporary reduction of competing vegetation is achieved. Broadcast treatments increase herbaceous species and reduce woody species.

Prescribed burning at a 4-year cycle (Coastal Plain) and 6-year cycle (Piedmont) adequately controls the buildup of hazardous fuels. Growing and dormant season burns are used to produce a mix of woody and herbaceous mid- and understory species. Where growing season burns are used a greater number and variety of herbaceous species will be produced. Use of higher-intensity fire in this alternative further reduces woody species and increases herbaceous species. Range burns on a 3-year cycle sustain a mix of preferred range forage species consisting of native grasses, forbs, and legumes.

Mechanical tools causing low to high soil disturbance are used. Herbaceous species initially increase, then decline within 3 to 5 years, depending upon tool intensity. Woody species initially decline. Higher intensity tools or combinations produce a greater decline. Some mortality of woody species occurs through uprooting by raking and disking. Most woody species fully recover within 5 to 10 years following treatment.

Low to moderate amounts of manual methods are used, causing repeated treatments on sites with high numbers of competing stems in order to successfully release or precommercially thin pine and hardwood seedlings or saplings. No biological methods are used.

**Wildlife and  
Aquatic Animals**

A wide range of vegetation management tools provides a variety of habitats and successional stages for many species. Deer and turkey populations benefit from prescribed burning, opening maintenance, and other habitat improvement treatments. Prescribed burning frequencies are



similar to alternative E, but some intense burns occur, providing very early successional stage habitat. Mast producers are often not favored due to use of non-selective treatments. Fewer snags for cavity nesters and downed logs for reptiles and amphibians are created than in alternative E.

Threatened,  
Endangered,  
Proposed, and  
Sensitive Species

All methods are available for habitat management. Mitigation measures assure adequate inventory of threatened, endangered, proposed, and sensitive species and protect populations from adverse effects of vegetation management. Recovery is likely if impacts from external factors are controlled.

Soil

Underburns occur every 4 years in the Coastal Plain, 6 years in the Piedmont, and 2 years in habitat for threatened and endangered species. Use of growing season burns is significant. Slash burns compose 25 percent of site preparation acres and are estimated to be 30 percent light, 50 percent moderate, and 20 percent severe. Piling and raking compose 21 and 5 percent of site preparation acres, respectively. Biological methods are not used.

In general, 2-year underburns pose medium risks to soil productivity. Other underburns, moderate slash burns, and piling pose low risk to poor soils only, but growing season underburns increase risk where they are used. Severe slash burns and raking pose high risk on good soils and extreme risk on poor and fair soils. Effects of all other tools are minimal. Over time, risk to soil productivity from vegetation management is estimated to be low on 263,700 acres, medium on 78,800 acres, high on 192,800 acres, and extreme on 41,200 acres.

Water

Nearly all sediment is caused by non-manual site preparation and broadcast herbicide use on roadsides and utility lines (projected 49,426 and 6,810 acres per year, respectively.) Treatment intensity is low to high, producing about 1,270 tons of sediment per year. Effects on stormflows and herbicide concentrations are minimal.

Wildfire and  
Air Quality

Slash burns are projected to occur on 12,481 acres per year, underburns on 450,595 acres per year, and wildfires on 12,000 acres per year. Annual smoke emissions from national forest lands are estimated to average 41,400 tons from prescribed fire and 3,100 tons from wildfire, for a total of 44,500 tons.

ROW Corridors

Treatment methods for effective control are available and target species are controlled. Species having desired height, width, and density are favored. Plant species are promoted to enhance wildlife habitat and food, provide recreation potential and aesthetic value, and reduce overall maintenance costs.

## Visual Quality

Visual impacts result from prescribed fire, mechanical, and herbicide treatments. Visitors viewing treated areas see significant vegetation disruption and ground disturbance for 3 to 6 months after treatments. If piled debris isn't burned, this effect stays visible for 2 to 3 years. Treatments may meet visual quality objectives for retention to maximum modification.

## Cultural Resources

Alternative F allows the full range of mechanical treatments, low to high soil disturbance, and the greatest risk of effects, except for alternative H which treats more acres.

## Socioeconomic Conditions

Alternative F provides a moderate level of employment opportunity. All expectation levels are managed, with semi-primitive motorized class and roaded-natural class having the most acres. Total program costs are \$8.80 million, higher than all other alternatives except H. Per-acre costs are highest at \$15.90.

## Alternative G

**Prescribed fire and herbicides are the favored means of vegetation control. Minimum risk herbicides are applied by hand, machine, and air. Mechanical tools cause low to moderate disturbance. Prescribed fire is of low to moderate intensity. Acres treated per year total 553,500.**

## Human Health and Safety

About 1.8 times as many acres are treated with herbicides than currently. Increase in acreage treated with herbicides exposes more individuals and increases potential for accidental spill. However, additional mitigation, including use of minimum-risk herbicides and application methods, increases individual safety.

Increased treated acreage could increase visitor exposure. If posted warning signs are observed, however, no exposure should occur. Drift from aerial operations is not a problem if management requirements and mitigation measures in chapter II are followed. No negative public health effects are projected at typical application rates.

## Vegetation

Increased use of herbicide treatments, plus introduction of aerial application by helicopter, puts non-target vegetation at a higher risk.

Prescribed burning at a 4-year cycle (Coastal Plain) and 6-year cycle (Piedmont) adequately controls the buildup of hazardous fuels. Low to moderate intensity, growing and dormant season burns at these cycles produce a mix of woody and herbaceous mid- and understory species. Growing season burns, however, can be expected to produce a greater number and variety of herbaceous species. Range burns on a 3-year cycle sustain a mix of preferred range forage species consisting of native grasses, forbs, and legumes.

Mechanical tools causing low to moderate soil disturbance are used. Herbaceous species initially increase, then decline within 3 to 5 years, depending upon tool intensity. Woody species initially decline. Higher-intensity tools or combinations (such as shearing and piling or bedding) produce a greater decline. Since no raking or heavy disking occurs, mortality of woody species through uprooting is very low. Woody species fully recover within 5 to 10 years following treatment.

Low amounts of manual methods are used. Some repeated treatments occur on sites with high numbers of competing stems in order to successfully release or precommercially thin pine and hardwood seedlings or saplings.

Areas using grazing as a biological control method have some pine and hardwood seedling losses from plant injury and mortality. Heavy grazing intensities cause shifts in herbaceous species composition.

Wildlife and  
Aquatic Animals

Management is similar to alternative F. An increase in broadcast herbicide application reduces hard- and soft-mast producers used by many animals including deer, turkey, and squirrel on some sites, but use of selective methods favors mast producers on others. Prescribed burning frequencies and intensities produce effects similar to alternative E. Low use of mechanical tools leaves snags for raptors but fewer downed logs for reptiles and amphibians.

Threatened,  
Endangered  
Proposed, and  
Sensitive Species

All methods are available for habitat management. Mitigation measures assure adequate inventory of threatened, endangered, proposed, and sensitive species and protect populations from adverse effects of vegetation management. Recovery is likely if impacts from external factors are controlled.

Soil

Underburns occur every 4 years in the Coastal Plain, 6 years in the Piedmont, and 2 years in habitat for threatened and endangered species. Use of growing season burns is significant. Slash burns compose 30 percent of site preparation acres and are estimated to be 50 percent light and 50 percent moderate. Piling composes 21 percent of site preparation acres, but raking is not used. Use of biological methods is minor.

In general, 2-year underburns pose medium risk to soil productivity. Other underburns, moderate slash burns, and piling pose low risk to poor soils only, but growing season underburns increase risk where they are used. Biological methods pose high risk from heavy grazing. Effects of all other tools are minimal. Over time, risk to soil productivity from vegetation management is estimated to be low on 271,500 acres and medium on 78,800 acres.



Water	Nearly all sediment is caused by non-manual site preparation and broadcast herbicide use on roadsides and utility lines (projected 49,426 and 22,118 acres per year, respectively). Herbicides and prescribed fire are favored for site preparation, and low to moderate treatment intensity produces about 810 tons of sediment per year. Effects on stormflows and herbicide concentrations are generally minimal. Aerial treatments, however, pose risk of accidental direct application of herbicides to streams.
Wildfire and Air Quality	Slash burns are projected to occur on 19,471 acres per year, underburns on 447,567 acres per year, and wildfires on 12,000 acres per year. Annual smoke emissions from national forest lands are estimated to average 42,000 tons from prescribed fire and 3,100 acres from wildfire, for a total of 45,100 tons.
ROW Corridors	Treatment methods for effective control are available and target species are controlled. Species having desired height, width, and density are favored. Plant species are promoted to enhance wildlife habitat and food, provide recreation potential and aesthetic value, and reduce overall maintenance costs.
Visual Quality	Visual impacts result mostly from prescribed fire and herbicide treatments. Effects from most prescribed fire should be negligible after 3 to 4 months. Broadcast herbicide applications create seasonal browning that attracts viewer attention. Treatments meet visual quality objectives from retention to maximum modification.
Cultural Resources	Fewer acres treated mechanically, and use of tools causing low to moderate disturbance except for ripping and bedding, reduce risks from present.
Socioeconomic Conditions	Alternative G favors experiences nearer the primitive end of the scale. Social conflict is affected by this attention to primitive expectations and the addition of aerial herbicide application. Total costs are about \$8.37 million and per-acre costs are \$15.11, about 5 percent less than present.
<b>Alternative Modified G</b>	<b>This alternative modifies alternative G by reducing total herbicide use (shifting to more mowing on roadsides and utility lines) as well as broadcast (ground and aerial) herbicide use. Biological methods are also eliminated.</b>
Human Health and Safety	About 1.5 times as many acres are treated with herbicides than currently. Increase in acreage treated with herbicides exposes more individuals and increases potential for accidental spill. However, additional mitigation, including use of minimum-risk herbicides and application methods, and an increase in selective application increases individual safety. Reduced treatment acreage from alternative G lowers risk from that alternative. Despite increasing treatment acreage, mitigations reduce overall risk to a level lower than in alternative F.

Increased treated acreage could increase visitor exposure. If posted warning signs are observed, however, no exposure should occur. Potential for drift from aerial application of herbicides is less than in alternative G since only 2,500 acres are expected to be aerially sprayed. Drift from aerial operations is not a problem if management requirements and mitigation measures in chapter II are followed. No negative public health effects are projected at typical application rates.

#### Vegetation

Increased use of herbicide treatments, plus introduction of aerial application by helicopter, puts non-target vegetation at slightly higher risk than in the current program,. Risk is less than in either alternative G or H due to the use of more selective methods of application and less treated acreage.

Prescribed burning at a 4-year cycle (Coastal Plain) and 6-year cycle (Piedmont) adequately controls the buildup of hazardous fuels. Low to moderate intensity, growing and dormant season burns at these cycles produce a mix of woody and herbaceous mid- and understory species. Growing season burns, however, can be expected to produce a greater number and variety of herbaceous species. Range burns on a 3-year cycle sustain a mix of preferred range forage species consisting of native grasses, forbs, and legumes.

Mechanical tools causing low to moderate soil disturbance are used. Herbaceous species initially increase, then decline within 3 to 5 years, depending upon tool intensity. Woody species initially decline. Higher-intensity tools or combinations (such as shearing and piling or bedding) produce a greater decline. Since no raking or heavy disking occurs, mortality of woody species through uprooting is very low. Woody species fully recover within 5 to 10 years following treatment.

Low amounts of manual methods are used. Some repeated treatments occur on sites with high numbers of competing stems in order to successfully release or precommercially thin pine and hardwood seedlings or saplings.

#### Wildlife and Aquatic Animals

Management is similar to alternative G. Broadcast herbicide application on some sites reduces hard- and soft-mast producers used by many animals including deer, turkey, and squirrel on some sites, but increased use of selective methods favors mast producers on others. Prescribed burning frequencies and intensities produce effects similar to alternative E. Compared to alternative F, low use of mechanical tools leaves snags for raptors but fewer downed logs for reptiles and amphibians.

Threatened,  
Endangered  
Proposed, and  
Sensitive Species

All methods are available for habitat management. Mitigation measures assure adequate inventory of threatened, endangered, proposed, and sensitive species and protect populations from adverse effects of vegetation management. Recovery is likely if impacts from external factors are controlled.

Soil

Underburns occur every 4 years in the Coastal Plain, 6 years in the Piedmont, and 2 years in habitat for threatened and endangered species. Use of growing season burns is significant. Slash burns compose 30 percent of site preparation acres and are estimated to be 50 percent light and 50 percent moderate. Piling composes 21 percent of site preparation acres, but raking is not used. Biological methods are not used.

In general, 2-year underburns pose medium risk to soil productivity. Other underburns, moderate slash burns, and piling pose low risk to poor soils only, but growing season underburns increase risk where they are used. Effects of all other tools are minimal. Over time, risk to soil productivity from vegetation management is estimated to be low on 271,500 acres and medium on 78,800 acres.

Water

Nearly all sediment is caused by non-manual site preparation and broadcast herbicide use on roadsides and utility lines (projected 49,426 and 12,055 acres per year, respectively). Herbicide use is more selective than in alternative G, so low to moderate treatment intensity produces about 670 tons of sediment per year. Effects on stormflows and herbicide concentrations are generally minimal. Aerial treatments pose risk of accidental direct application of herbicides to streams, but this risk is a fraction of that in alternative G.

Wildfire and  
Air Quality

Slash burns are projected to occur on 19,471 acres per year, underburns on 447,567 acres per year, and wildfires on 12,000 acres per year. Annual smoke emissions from national forest lands are estimated to average 42,000 tons from prescribed fire and 3,100 acres from wildfire, for a total of 45,100 tons.

ROW Corridors

Treatment methods for effective control are available and target species are controlled. Species having desired height, width, and density are favored. Plant species are promoted to enhance wildlife habitat and food, provide recreation potential and aesthetic value, and reduce overall maintenance costs.

Visual Quality

Visual impacts result mostly from prescribed fire and herbicide treatments. Effects from most prescribed fire should be negligible after 3 to 4 months. Broadcast herbicide applications create seasonal browning that attracts viewer attention. Treatments meet visual quality objectives from retention to maximum modification.



Cultural Resources      Fewer acres treated mechanically, and use of tools causing low to moderate disturbance except for ripping and bedding reduces risks from present.

Socioeconomic Conditions      This alternative favors experiences nearer the primitive end of the scale. Social conflict is affected by this attention to primitive expectations. Reaction to aerial application of herbicides is not as severe as in alternative G. Total costs are about \$8.43 million and per-acre costs are \$15.23.

Alternative H      Vegetation management is done to achieve maximum vegetation control. Herbicides are broadcast at maximum effective rates by hand, machine, and air. High disturbance mechanical tools and intense prescribed fires are used more frequently than at present. Repeat entries occur on highly productive lands. Acres treated per year total 801,000.

Human Health and Safety      Aerial application of herbicides reduces average risk to herbicide applicators. About twice as many acres, however, are treated than currently, so more workers are exposed and the probability of an accidental spill increases. Because effectiveness of control is the major concern, human health and safety are important but less emphasized.

Due to increased acres treated and higher than current application rates, risk to public health is projected to increase. Visitors obeying posted warnings should not be exposed to herbicides in treated areas and so are not at risk.

Increased use of fire to control unwanted vegetation is expected to lead to an increase in the number of tripping, falling, and slipping injuries. Smoke inhalation and relatively minor injuries will increase, but no significant increase in disabling injuries occurs from present.

Vegetation      Increased acreage treated using herbicides, and increased frequency and intensity of treatments, permit almost complete control of competing woody or herbaceous vegetation and puts non-target vegetation at highest risk. Broadcast herbicide application by helicopter, mechanical sprayers, or hand ground tools occurs on 65,500 acres.

Prescribed burning at a 3-year cycle (Coastal Plain) and a 5-year cycle (Piedmont) more than adequately controls the buildup of hazardous fuels. Growing and dormant season burns at these cycles produce a mix of woody and herbaceous mid- and understory species. Reductions in some woody species reproduction and development occurs, and greater numbers of herbaceous species predominate. Use of higher intensity fire also reduces woody species and increases herbaceous species. Range burns on a 2-year cycle maintain high amounts of primarily grass species, as well as some forbs and legumes.

Mechanical tools causing low to high soil disturbance are used. Herbaceous species initially increase, then decline within 3 to 5 years, depending upon tool intensity. Woody species initially decline. Higher-intensity tools or combinations produce a greater decline. Some mortality of woody species occurs through uprooting by raking and disking. Most woody species fully recover within 5 to 10 years following treatment.

Areas using grazing as a biological control method have some pine and hardwood seedling losses from plant injury or mortality. Heavy grazing intensities cause shifts in herbaceous species composition.

Wildlife and  
Aquatic Animals

Maximum vegetation control limits production of hard- and soft-mast and browse used by deer, turkey and other species. Higher burning intensity and frequency combined with herbicide treatments severely reduce hardwood midstories used by songbirds like tufted titmouse (Parus bicolor), but may increase soft mast production. Increased siltation from intensive treatments impairs quality of aquatic habitats. Snags for raptors and downed logs for reptiles and amphibians are less available than in other alternatives.

Threatened  
Endangered,  
Proposed, and  
Sensitive Species

All methods are available for habitat management. Mitigation measures assure adequate inventory of threatened, endangered, proposed, and sensitive species and protect populations from adverse effects of vegetation management. Recovery is likely if impacts from external factors are controlled.

Soil

Underburns occur every 3 years in the Coastal Plain, 5 years in the Piedmont, and 2 years in habitat for threatened and endangered species. Use of growing season burns is significant. Slash burns compose 15 percent of site preparation acres and are estimated to be 20 percent light, 50 percent moderate, and 30 percent severe. Piling and raking each compose 18 percent of site preparation acres. Biological methods are used aggressively.

In general, 2-year underburns pose medium risk to soil productivity. Other underburns, moderate slash burns, and piling pose low risk to poor soils only, but growing season underburns increase risk where they are used. Severe slash burns and raking pose high risk on good soils and extreme risk on poor and fair soils. Biological methods pose high risk from heavy grazing. Effects of all other tools are minimal. Over time, risk to soil productivity from vegetation management is estimated to be low on 279,600 acres, medium on 192,800 acres, high on 551,400 acres, and extreme on 148,100 acres.

Water	Nearly all sediment is caused by non-manual site preparation and broadcast herbicide use on roadsides and utility lines (projected 49,925 and 19,750 acres per year, respectively). Broadcast herbicides, intensive mechanical techniques, and intense prescribed fire are favored. Treatments produce about 2,980 tons of sediment per year. Effects on stormflows and herbicide concentrations are generally minimal. Aerial treatments, however, pose the greatest risk of accidental direct application of herbicides to streams.
Wildfire and Air Quality	Slash burns are projected to occur on 7,488 acres per year, underburns on 659,586 acres per year, and wildfires on 9,000 acres per year. Annual smoke emissions from national forest lands are estimated to average 48,900 tons from prescribed fire and 2,300 tons from wildfire, for a total of 51,200 tons.
ROW Corridors	Treatment methods for effective control are available and target species are controlled. Species having desired height, width, and density are favored. Plant species are promoted to enhance wildlife habitat and food, provide recreation potential and aesthetic value, and reduce overall maintenance costs.
Visual Quality	This alternative creates significant visual impacts with more treatment acres meeting the maximum modification visual quality objective. Prescribed fire, mechanical, and herbicide treatments are used more and at higher intensity. These increases result in substantial visual color and textural changes readily noticed by visitors. Individual treatment effects may not meet the assigned visual quality objective to achieve other resource objectives.
Cultural Resources	The full range of mechanical treatments, causing low to high soil disturbance, pose the greatest risk of negative effects. More acres are treated than in other alternatives which also increases risk.
Socioeconomic	Intense practices strongly favor the rural experience. Those who favor primitive experiences are most negatively affected. Social conflict is similar to alternative G because aerial application of herbicides is available. Total costs are highest at \$12.62 million, and per-acre costs are \$15.75.

#### **O. RESEARCH NEEDS**

As this analysis was done, the need for more research was identified in several areas. Research is an integral part of work done on national forests and grasslands and is used to acquire knowledge of environmental processes and relationships. Information concerning effects of vegetation management, derived from existing research studies, form the basis for most of the conclusions of this document.



Following are the major research needs identified. Only items 1 through 5 relate to incomplete or unavailable information covered by 40 CFR 1502.22 and identified as data gaps in sections B, D, F, and G of this chapter. Items 6 through 19 are other important research needs.

1. Public, worker, and wildlife exposure from use of different herbicides and application rates.
2. Synergistic and cumulative effects of herbicides.
3. Herbicide effects on wildlife, including effects on habitat, chronic toxicity, and oncogenic and mutagenic potential.
4. Long-term effects on soil and water from varying severity of slash burns and from varying frequency and season of underburns.
5. Effects of vegetation management methods on streamflows and channel erosion, and rates of channel erosion in undisturbed forests.
6. Effects of prescribed burning on growth of different size classes of yellow pines.
7. Effects of alternating dormant and growing season burns on plant communities.
8. Composition, interrelationships, and potential indicator species of understory plant communities.
9. Long-range (multi-rotational) effects on wildlife and plants (especially threatened, endangered, proposed, and sensitive species) from vegetation management, including growing and dormant season burns.
10. Relationship of prescribed fire effects on wildlife (especially reptiles, amphibians, and songbirds) to fire behavior, including intensity, duration, and season.
11. Long-term effects on animals, especially threatened, endangered, proposed, and sensitive species, associated with plant communities that are treated with specific combinations of herbicides and periodic fire.
12. Competition between wildlife and domestic animals for available vegetation.
13. Long-term effects of intensive mechanical site preparation on soil, water, reptiles, and amphibians.

14. Movement of all 11 herbicides to streams and ground water, using typical application rates, over the full range of application methods and soil, geologic, and topographic conditions in the South.

15. Effects of increased sediment yield on aquatic species and their habitats.

16. Effects of prescribed fire on wildfire occurrence and air quality both locally and regionally.

17. Relationships between air pollution, CO<sub>2</sub> production, ozone layer depletion, and plant growth and reproduction.

18. Effects of bedding on seedling survival and understory plant communities.

19. Effectiveness of biological vegetation controls, including light inhibitors, livestock, insects, and allelopathic plants.

#### **P. ENERGY REQUIREMENTS**

The main energy source for vegetation management is fossil fuel. Every alternative except A consumes fuel (usually petroleum) either directly (such as in vehicles, machinery and equipment) or indirectly (such as an ingredient in herbicides or in a manufacturing process). Another energy source which is sometimes consumed is logging debris which has potential household or industrial uses.

Energy requirements for vegetation management are only a small part of the total energy required for all management activities on national forests. While there are variations between alternatives (A uses none and H requires the most), they are not significant.

#### **Q. POSSIBLE CONFLICTS WITH OTHERS**

Other local, State and Federal agencies have vegetation management programs of their own and may be affected by this analysis. Some of these agencies have overlapping responsibilities with the Forest Service, and some have administrative authorities to prescribe limits on certain types of adverse effects.

None of these agencies asked to be a formal cooperator under the provisions of the National Environmental Policy Act. However, many have participated in preparing this EIS:

- The Environmental Protection Agency has provided information on environmental standards and testing procedures.
- The Fish and Wildlife Service has assisted with data and requirements for compliance with the Endangered Species Act.

- The Tennessee Valley Authority has assisted with rights-of-way analysis and provided cost statistics.
- State Foresters have been represented by two part-time team members and have reviewed some analytical results.
- Chapter VI contains a list of agencies at all levels which reviewed the Draft EIS.

Few conflicts with others have been noted. One is that management intensities on national forests can be expected to differ from those on other lands. The uninformed visitor could have unrealistic expectations that all lands should have similar management, particularly when they are adjacent. Management intensities will differ depending on the objectives of the responsible agency.



Alternatives A and B reduce payments to local governments. Selection of either of these alternatives requires more intense coordination with these governments because both envision substantial program revisions.

The most significant potential conflict is internal; with Forest Land and Resource Management Plans. Plans assumed that all vegetation management methods are available. The Regional Forester's decision about which mix of methods to use, based on this analysis, could be different from assumptions in Plans. Forest Supervisors will evaluate the Regional Forester's decision and its effect on Plans and make revisions as needed.

#### **R. ADVERSE EFFECTS THAT CANNOT BE AVOIDED**

Despite mitigation measures, some significant adverse effects are unavoidable, some in alternative A only, and some in any alternative where vegetation management is done. These effects are:



- 1. Health and Safety** Worker accidents occur through use of vegetation management methods.
- 2. Vegetation** Individual non-target plants are injured or killed by vegetation management. Some methods and tools have greater effects than others. Following intensive mechanical treatments, some native plant communities, especially pine-wiregrass types, may not return via succession to their pre-disturbance states.
- 3. Wildlife and Aquatic Animals** Wildlife requiring mature forests is displaced or lost from some habitats by vegetation management which prolongs early stages of plant succession. Wildlife requiring open areas is displaced as young stands age, especially in alternatives A and B.
- 4. Threatened, Endangered, Proposed, and Sensitive Species** Lack of vegetation management in alternative A reduces populations or prevents recovery of some animals and plants that can exist only in forests experiencing periodic disturbances.
- 5. Soil** Soil productivity is impaired where methods cause excessive loss of soil organisms, organic matter, and nutrients in alternatives F and H.
- 6. Water** Water quality is impaired in some small streams that drain areas where high disturbance tools are used in alternatives F and H, or that are accidentally overflowed during aerial herbicide application in alternatives G, Modified G, and H.
- 7. Air Quality** Smoke from prescribed fires or wildfires temporarily impairs air quality in every alternative.
- 8. Rights-of-Way** Lack of treatment in alternative A allows vegetation to encroach on rights-of-way, threatening public safety on roads and trails and impairing operation of utility lines.
- 9. Visual Quality** Visual quality is temporarily impaired by vegetation management methods. Lack of treatment in alternatives A and B may also cause impairment.
- 10. Wildfire** Lack of prescribed fire in alternative A and limited use in alternative B allow fuels to build to dangerous levels and increase probability and severity of wildfire damage.
- 11. Socioeconomic Conditions** Any action or lack of action is acceptable to some people and unacceptable to others. This disagreement creates social conflict about vegetation management. Conflict is created whenever there are changes from current ways of doing things.
- S. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES** An irreversible commitment is one in which nonrenewable resources are permanently lost. Such losses occur because oil, gas, coal, or petroleum products are consumed and cannot be replaced. Some endangered plants occurring only

on national forests may be irreversibly lost in alternative A. Repeated intensive mechanical treatments may cause long-term loss of some native plant communities (especially pine-wiregrass types) that would decrease overall biological diversity. Soil productivity may be impaired for many decades on sites where raking or severe slash burns are used in alternatives F and H.

An irretrievable commitment is one in which resource production or use is lost while managing an area for another purpose. If we choose not to manage a resource, we do so knowing we lose its potential value had it been managed. All alternatives eliminate or reduce management of some resources, while emphasizing others.

This EIS makes no irreversible or irretrievable commitment of resources. This EIS displays the projected effects of vegetation management for the activities listed in chapter I. Any irreversible or irretrievable commitment of resources will occur at the site-specific level and be accompanied by site-specific analysis that discloses the environmental effects.



#### **T. SHORT-TERM USES AND LONG-TERM PRODUCTIVITY**

National forests must be managed to protect long-term productivity of the land. Long-term productivity is the capability of forests to provide resources into the future. Most management activities and resource outputs are short-term uses. When decisions are made to produce these outputs, long-term productivity could be affected. Generally, mitigation measures reduce or eliminate effects on long-term productivity by protecting soil, water, wildlife, and threatened and endangered plants and animals. Where raking or severe slash burns are used, however, loss of long-term soil productivity is inevitable.

Monitoring requirements which apply to all alternatives are designed to provide feedback to managers who ensure that long-term productivity is not impaired by short-term uses. If monitoring discloses that management requirements and mitigation measures are inadequate, new ones will be developed.





## CHAPTER V

### LIST OF PREPARERS

#### A. INTERDISCIPLINARY TEAM SELECTION

The Regional Forester and his staff evaluated the need to prepare an environmental impact statement and identified activities which needed to be analyzed. Once analysis needs were known, a team leader was selected and the team leader and Regional Forester looked at the Region's work force to locate individuals with education and experience necessary to complete the analysis.

Team members listed below represent a broad mix of experience and specialized training. Specialties cover a wide range of resources and all members are highly experienced in natural resource and human resource management. The team prepared this EIS. Some of the work they did was identifying and examining issues, developing and evaluating alternatives, researching and analyzing environmental effects, and studying and responding to public comments.

#### B. FULL-TIME TEAM MEMBERS

Steve McCorquodale is the team leader. He has a Bachelor of Science degree in Forestry from McNeese State University at Lake Charles, Louisiana. Steve is completing his 24th year with the Forest Service and has had assignments in North Carolina, Texas, Virginia, Mississippi, Kentucky, Alabama, and Georgia. His principal area of expertise is in fire management. In addition, his previous positions have given him responsible administrative and supervisory experience in recreation, silviculture, public affairs, minerals, and wilderness. Steve is an avid hunter and fisherman and pursues his interests in natural resources through active memberships in Society of American Foresters and American Forestry Association.

Interdisciplinary Team responsibilities include overall management and supervision as well as coordination with others and accountability to management.

Ann Cason is the program assistant. She has specialized secretarial education through several Office of Personnel secretarial, business management, and administration courses. Ann is completing her 26th year of Federal service and has had assignments with the Environmental Protection Agency, Department of Justice, U. S. Geological Survey, Department of Defense, and for the last eight years with the Forest Service. Assignments in positions such as administrative technician, clerk-stenographer, secretary, and executive secretary have given her broad administrative experience. Ann enjoys gardening and walking.

Her responsibilities on the team include internal and external scheduling, correspondence, computer management, financial management and travel coordination.

Jim Maxwell is the team hydrologist. He has a Bachelor of Science degree in Forest Hydrology from Utah State University at Logan, Utah. Jim is completing his 18th year with the Forest Service and has had assignments in California, Utah, Idaho, West Virginia, Oregon, New Mexico, and Georgia. His principal area of expertise is in streamflow-sediment dynamics. In addition his previous positions have given him supervision and administration experience in stream and fisheries protection, rainfall-runoff relationships, and influence of climate. Jim is an avid hiker and river floater.

Responsibilities as a team member are for analysis of soil, water and air resources and evaluation of cumulative effects.

Paul A. Mistretta is the team plant pathologist. He has a Bachelor of Science degree in Biology from Fordham College, New York, New York, a Master of Forestry degree (forest protection) from Duke University, Durham, North Carolina, and a Doctor of Philosophy in plant science from the University of Maine at Orono. Paul is completing his 11th year with the Forest Service and has had assignments in Georgia and Louisiana. His principal area of expertise is in epidemiology of forest tree diseases. He also has two years experience as a graduate teaching assistant. He has authored or coauthored over 40 publications and is active in several professional societies. Paul enjoys philately and computer programming.

Responsibilities as a team member are for coordination of risk assessment, toxicology and rights-of-way analyses and incorporation of those analyses into the EIS.

Jane Sell is the editorial assistant. She has enhanced her skills through on-the-job training. Jane is completing her 15th year with the Forest Service and has had assignments as clerk-typist and clerk-stenographer. Her experience as owner-operator of a printing company for 12 years and additional administrative-editorial experience with other environmental documents with the Forest Service give her broad qualifications. Jane actively pursues outdoor sports.

Team support responsibilities are to manage filing and data systems, to assist with edit and layout, and to coordinate literature search.

Gary Sick is the team public affairs specialist. He has a Bachelor of Science degree in Geological Sciences from the State University of New York at Geneseo, New York and a Master of Science degree in Forestry (policy analysis) from Michigan State University at East Lansing, Michigan. Gary

is completing his 11th year with the Forest Service and has had assignments in Mississippi, Arkansas, Michigan and Georgia. His principal area of expertise is in minerals management. In addition, his previous positions have given him responsible management experience in data management, environmental planning, and water quality analysis. Earlier experience includes three years in social work and one year in public schools. Gary enjoys most outdoor recreation, especially fishing.

Responsibilities on the team are NEPA compliance, scoping, media and document production.

Cynthia A. Witkowski is the team silviculturist. She has a Bachelor of Science degree in Natural Resource Conservation from the University of Connecticut at Storrs, Connecticut. Cindy is completing her 12th year with the Forest Service and has had assignments in South Carolina, Arkansas, Louisiana and Georgia. Her principal area of expertise is in timber and silviculture. Her positions have also given her responsible management experience in administration, recreation, minerals, wildlife and human resources. Two years with the Peace Corps also gave her broad natural resource management skills. Cindy enjoys golf and fishing and is an active member of the Society of American Foresters.

Team responsibilities are analysis and coordination of silviculture, wildlife and range.

#### **C. PART-TIME TEAM MEMBERS**

Joel Artman is a team member from the Virginia Department of Forestry. He attended the University of Tennessee; received a Bachelor of Science degree in Forest Management from North Carolina State University and a Masters degree from Duke University in Forest Pathology. Joel has been with the Virginia Department of Forestry for about 25 years and currently occupies the position of Chief of the Pest Management Branch. One of his primary duties involves the operational and testing efforts in chemical site preparation and pine release for the Department's pesticide program. He enjoys crocheting and woodworking during the winter, while summer's spare time is occupied canoeing, camping, and messing with snakes.

Part-time responsibilities include input and review for herbicide use, aerial application and liaison with Southern Group of State Foresters.

Edwin H. Barron has a Bachelor of Science degree in Forestry from Louisiana Polytechnic University at Ruston, Louisiana, and a Master of Forestry degree from Stephen F. Austin State University at Nacogdoches, Texas. Ed is completing his 22nd year with the Texas Forest Service. His principal areas of expertise are forest management and program administration. In his current position as head of the Forest Management



Department, he is responsible for providing overall direction, planning and administration for the agency's forest management and pest control programs. He serves as a principal staff officer to the Director of the Texas Forest Service. He is a member of the Society of American Foresters and the Texas Forestry Association.

Responsibilities as a team member are providing technical advice and reviewing alternatives for vegetative management practices.

Jim Fenwood is the team wildlife biologist. He has a Bachelor of Science degree in Wildlife Management from the University of Maine at Orono, Maine, and a Master of Science degree in Wildlife Management from West Virginia University at Morgantown, West Virginia. Jim is completing his 11th year with the Forest Service and has had assignments in Arkansas and South Carolina. His principal area of expertise is forest wildlife management. In addition his positions have given him responsible management experience in fire, range, watershed, and recreation. Jim is a Certified Wildlife Biologist and active member of the Wildlife Society, National Audubon Society, and other conservation organizations. He enjoys outdoor writing, photography, and hunting.

Team responsibility is for analysis of effects on wildlife habitat and on threatened, endangered and sensitive species.

Richard Greenhalgh is the Southern Region's economist, and provides economic analysis support on a part-time basis. He has a Bachelor of Science degree in Vocational Education and a Master of Science degree in Agricultural Economics from University of Nebraska, and a Doctor of Philosophy with emphasis in Natural Resource Economics from the University of Missouri. His experience includes 15 years of research and river basin studies throughout the Southeast with the USDA Economics Research Service, and 9 years as an economist with the Forest Service.

Gerald Helton is the team sociologist. He has a Bachelor of Arts degree in Psychology from Morehouse College, Atlanta, Georgia, and a Master of Arts degree in Social Service Administration from the University of Chicago, Chicago, Illinois. Gerald is completing his 12th year with the Forest Service and has worked in Atlanta, Georgia during that period. He has earlier experience working for three years for the City of Atlanta as an Employment Counselor. Gerald's principal area of expertise is in management/supervisory training. He also has experience in team building and group dynamics. He enjoys reading, photography, and spectator sports and is an active member of Toastmasters International.

Responsibility as a team member is for social analysis.

Jerry Lee Michael holds a B.S. in chemistry from Elon College, master's degree in plant taxonomy from the University of North Carolina at Chapel Hill, and a Doctor of Philosophy in tree physiology from Colorado State University.

He spent two years in the army as a plant physiologist at Fort Detrick, Maryland. After completing his Ph.D. at Colorado, he went to the University of Georgia as a post-doctoral fellow where he worked on host-physiology related aspects of the southern pine beetle problem and on the physiology of paraquat induced resin soaking in southern pines. He is currently employed by the Southern Forest Experiment Station, Forest Service at Auburn University, Auburn, Alabama. His primary work has been research on environmental chemistry of the principal herbicides used in forestry including the immediate and ultimate fate of herbicides applied to forest ecosystems.

Responsibilities as a part-time team member are for analysis and evaluation of herbicide effects.

Dan Neary is the team soil scientist. He has a Bachelor of Science degree in Forestry, a Master of Science degree in Forest Ecology, and a Doctor of Philosophy degree in Forest Soils and Hydrology, all from Michigan State University at East Lansing. Dan is completing his 11th year with the Forest Service. He has had assignments with the New Zealand Forest Research Institute and the Cowetta Hydrologic Laboratory, North Carolina, and is currently part of the Intensive Management Practices Assessment Center, Southeastern Forest Experiment Station at the University of Florida. His principal area of expertise is in the environmental fate and effects of forestry pesticides, but he also has considerable experience with the effects of intensive forestry on soils, site productivity, and water quality. He has authored or co-authored over 65 publications, and is active in numerous scientific organizations. Dan enjoys swimming, sailing, and skiing.

Responsibilities as a part-time team member are for analyses and evaluation of herbicide effects, soil and water impacts, and cumulative watershed effects.

Dennis Robertson has a Bachelor of Science degree in Landscape Architecture from the University of Missouri at Columbia, Missouri. He is completing his 22nd year with the Forest Service with assignments in Washington, Wyoming, Arkansas, and Georgia. His principal area of expertise is in resource planning. In addition, his previous assignments have given him responsible management experience in recreation management, facilities design, landscape management, and rights-of-way design.

Dennis enjoys many outdoor sports and yard work, and maintains an active membership in the National Arbor Day Foundation.

Responsibilities as a team member are for analysis of visual quality and rights-of-way maintenance techniques.

Joan Walker is the team plant ecologist. She received a Bachelor of Science degree in Biology from Lebanon Valley College, Annville, Pennsylvania and Master of Science and Doctor of Philosophy degrees in Botany from the University of North Carolina, Chapel Hill. She has had post-doctoral research experience at Duke University, and held an Assistant Professor position at Southeastern Louisiana University, Hammond. She has had 8 years of experience working in ecosystems of the Southeast, with an emphasis in coastal plain communities. Primary research concerns have included diversity and production in fire-dependent savannas and flatwoods.

Joan compiled information on threatened, endangered, and sensitive species habitats, and coordinated an effort to assess the effects of management techniques on TES species.

Max Williamson is the Regional Pesticide Specialist. He has a Bachelor of Science degree in Chemistry from Cumberland College at Williamsburg, Kentucky, and the Master of Science degree in Environmental Engineering from Murray State University at Murray, Kentucky. He has completed additional graduate studies in Physical Sciences and Toxicology. He is completing his 26th year with the Forest Service and has broad experience as a pesticide specialist and resource management. His assignments have been in California, Virginia, North Carolina, Arkansas, Oklahoma, and Georgia.

Responsibility as a team member is to serve in an advisory capacity, and to act as liaison with industry and regulatory bodies.

Tom Wiseman is a writer-editor with the team. He has a Bachelor of Arts degree in English from the Pennsylvania State University at University Park, Pennsylvania. He also earned a Master of Arts and a Ph.D in English from Tulane University in New Orleans, Louisiana. He served as writer-editor with the Forest Service's Southern Forest Experiment Station for 2 years. Additionally, he edited Forest Farmer magazine for 8 years. He is now assistant professor of English at Southern College of Technology in Marietta, Georgia. Tom enjoys fishing, coaching youth basketball, and creative writing.

Team responsibilities include copy editing and writing, assisting with layout and design, and proofreading.



**D. ADVISORS,  
CONSULTANTS AND  
REVIEWERS**

**1. Advisors**

Stanford Adams, USDA Forest Service, Public Affairs  
Larry Bishop, USDA Forest Service, Coop Forestry  
Steve Dornseif, USDA Forest Service, Systems Support  
Chris Glover, USDA Forest Service, Systems Support  
Harold Greenlee, USDA Forest Service, Geometronics  
Douglass Hattersley, USDA Forest Service, Lands and Minerals  
Jimmy Huntley, USDA Forest Service, Fisheries and Wildlife  
Jean Kruglewicz, USDA Forest Service, NEPA Compliance  
Yvonne Knaebel, USDA Forest Service, Appeals & Litigation  
Jim Lunsford, USDA Forest Service, Fire  
Keith McLaughlin, USDA Forest Service, Soil, Water and Air  
Bob Stignani, USDA Forest Service, Recreation  
Jimmy Walker, USDA Forest Service, Timber/Silviculture

**2. Risk Assessment  
Review**

Joanne E. Betso, Dow Chemical USA  
Jim Brewer, JLB International Chemicals  
E. Calabrese, University of Massachusetts  
Sean Casey, Elanco Products  
Dave Clapp, Centers for Disease Control  
Bob Cooke, USDI Fish and Wildlife Service  
Edwin Dale, Private citizen  
Ed Daley, International Paper  
Tom Darden, USDA Forest Service  
Dean Gjerstad, Auburn University  
Jack Gnegy, Westvaco  
Larry Gross, USDA Forest Service  
Simon K. Hall, American Cyanamid  
Zdenka Horakova, USDA Forest Service  
George Hurst, Mississippi State University  
Kentucky Power Co.  
Kentucky Utilities Co.  
Timothy J. Long, Montsanto Co.  
Bob Lowery, Weyerhaeuser  
Bill McComb, Oregon State University  
Jerry L. Michael, USDA Forest Service  
Hans Muller, US Environmental Protection Agency  
Fredrick O. O'Neal, E.I. Dupont Co.  
Bill Pope, Potlach  
John Taylor, USDA Forest Service  
R. Thomas, National Academy of Sciences  
Shep Zedacker, Virginia Polytechnic Institute

**3. Technical  
Consultants and  
Review**

Richard Ames, USDA Forest Service  
Thomas M. Armitage, US Environmental Protection Agency  
W. Wilson Baker  
Cathy Bowman, USDA Forest Service  
Ed Buckner, University of Tennessee  
Bill Carothers, USDA Forest Service  
Andre F. Clewell  
Jerry Clutts, USDA Forest Service  
Art Cram, Private citizen

George Dissmeyer, USDA Forest Service  
 Ronald Eislör, USDI Fish and Wildlife Service  
 Eric Ellwood, North Carolina State University  
 Ron Escano, USDA Forest Service  
 Roger Fryar, USDA Forest Service  
 Glen Glover, Auburn University  
 Robert K. Godfrey, Florida State University  
 Paul Hamel, Tennessee Department of Conservation  
 Dennis Harden, Florida Natural Resources Inventory  
 Jim Harrison, US Environmental Protection Agency  
 Gary Hasty, Tennessee Valley Authority  
 Isaac W. Hawkins, USDA Forest Service  
 John Hosner, Virginia Tech.  
 W. Wayne Johnson, USDI Fish and Wildlife Service  
 Bill Jones, Alabama Forestry Association  
 Dave Ketcham, USDA Forest Service  
 Ken Knauer, USDA Forest Service  
 Larry Landers, Tall Timbers Research Station  
 Gary Larsen, USDA Forest Service  
 Carlton R. Layne, US Environmental Protection Agency  
 Clifford Lewis, USDA Forest Service  
 William Mahan, SCWMRD  
 Brandt Mannchen  
 Gene McGee, USDA Forest Service  
 Bill McKee, USDA Forest Service  
 Bruce Means  
 Charles McMahon, USDA Forest Service  
 Edwin Michael, West Virginia University  
 James Miller, Auburn University  
 Patrick J. Minogue, Auburn University  
 Bob Mitchell, Auburn University  
 Logan Norris, Oregon State University  
 Max Ollieu, USDA Forest Service  
 Jim Paul, USDA Forest Service  
 Henry Pearson, USDA Forest Service  
 Steve Price, National Park Service  
 Jerry Ragus, USDA Forest Service  
 David Saugey, USDA Forest Service  
 Jesse T. Simmons, Tennessee Valley Authority  
 Rhey Solomon, USDA Forest Service  
 Peter Sprints, Texas A&M  
 Peter Swiderek, SCWMRD  
 Bennee Swindel, IMPAC, University of Florida  
 Richard Tallent, Tennessee Valley Authority  
 Ronald Thill, USDA Forest Service  
 David Van Lear, Clemson University  
 Dale Wade, USDA Forest Service  
 Tom Wojtalik, Tennessee Valley Authority  
 Tom Welborn, US Environmental Protection Agency  
 Carol Wells, USDA Forest Service  
 Carl S. Wilhelm, Jr., USDA Forest Service  
 Dale Wilhelm, Tennessee Valley Authority

# **Public Participation and Consultation With Others**

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## CHAPTER VI

### PUBLIC PARTICIPATION AND CONSULTATION WITH OTHERS

#### A. PUBLIC INVOLVEMENT SUMMARY

Because vegetation management issues are often intense and sometimes emotional, a high level of public participation was deemed necessary for satisfactory completion of this environmental impact statement. Therefore, the public has been actively involved in its development. Many people and organizations made valuable contributions to the analysis.

The Forest Service has encouraged public participation throughout EIS preparation. Steps taken to keep the public informed and involved are:

Notice of Intent - A notice of intent to prepare this EIS was published in the September 11, 1986, Federal Register. A revised Notice of Intent, based on early scoping results, was published in the May 5, 1987, Federal Register. This revision described methods which would be evaluated and estimated dates for public review of the draft statement and completion of the final statement.

Letter to the Public - The public was asked to identify issues through use of a post-paid mailer designed for this project. Over 11,000 of these mailers were distributed to interested individuals, groups and agencies in January 1987. To obtain the broadest possible coverage, each forest assembled a list of every party known to be interested in national forest management. These lists were then merged into a master list.

Media - Radio, television and the press were included in the request for comments on issues. A press release was also distributed to regional media by the Regional Public Affairs Office, and to state and local media by individual Forest Public Affairs Offices. The press release was done at the same time as mailers were sent, January 1987.

Meetings - On several occasions between January and August 1987, members of the interdisciplinary team and designated forest representatives met or spoke with agencies, groups and individuals whenever the level of interest called for such involvement. Needs varied from place to place with Texas, Florida and Georgia showing the most intense interest.

Tabloid - In May 1987, 6,000 tabloids with information about the scope, timing and progress of the EIS were distributed. Included in the tabloid were articles about issues, alternative themes, risk assessment, and methods proposed for use. A post-paid return envelope was inserted in the tabloid to allow for added public response. A coupon requesting a copy of the EIS or just inclusion on the mailing list was also printed to offer an opportunity to anyone who had not yet made the request.

Key Contacts - Other Federal agencies, congressional delegations, State agencies, State lawmakers, other Forest Service regions, and heads of organizations were contacted by phone and letter to inform them of project initiation. Accompanying the letter was an informational brochure describing the scope of the EIS and responding to commonly asked questions.

Risk Assessment - Recognizing that the risk assessment is a technical document with complex analyses, post cards were mailed to all respondents offering them an opportunity to request a draft risk assessment for review. This mailing was done during August and September 1987. About 35 percent of the addressees desired review copies.

Cooperators - No other agencies requested formal cooperator status, but many were consulted and contributed to the analysis. A unique form of cooperation was implemented for the risk assessment. Many State and Federal agencies and several utility companies were offered a chance to expand the scope of the risk assessment by evaluating additional herbicides used by them on their easements or permit areas on national forests. To do this they were required to fund the additional costs of analysis. Eleven utilities and the Tennessee Valley Authority elected to participate.

Responses - Public responses to the request for input on issues were catalogued into nine categories: elected officials; State and local government; Federal government; individuals; organizations; businesses; Forest Service employees; Forest Service retirees; and media. At the time of content analysis, March 1987, 813 responses had been received from 27 states and the District of Columbia (table VI-1. Ultimately, the total number of responses was 891.

Of the 813 responses in table VI-1, 756 or 92 percent came from states within the geographic area covered by this EIS. The highest percentage of contacts that responded came from Texas and Florida. Responses were organized into about 150 groups based on methods and affected resources. These groups were then analyzed for major themes called issues (chapter I). Alternatives (chapter II) were developed to respond to these issues.



Table VI-1.--Response distribution - Coastal Plain/Piedmont.

<u>State</u>	<u>Category</u>									<u>Total</u>
	<u>Elec Off.</u>	<u>St./Loc Gov't</u>	<u>Fed. Gov't</u>	<u>Indi- viduals</u>	<u>Organi- zations</u>	<u>Busi- nesses</u>	<u>Employ- ees</u>	<u>Retir- ees</u>	<u>Media</u>	
Alabama		8	2	51	6	6	6			79
Arkansas				4	3	1		2		10
Arizona				1				1		2
Colorado					1		1			2
Florida		17	1	48	17	13	11		3	110
Georgia		6	2	13	8	3	10	7		49
Kentucky				1		1				2
Louisiana		5	3	42	10	12	7			79
Michigan							1			1
Minnesota				1						1
Mississippi	1	7	1	41	7	10	6		1	74
Missouri						1				1
Montana					1					1
New Hampshire				1						1
New Jersey						1				1
New Mexico								1		1
New York				3						3
North Carolina		14	3	105	14	4	2	2	4	148
Ohio				2						2
Oklahoma			1	3						4
Oregon				1			1			2
Pennsylvania				2						2
South Carolina			3	21	5	6	2	5	1	43
Tennessee			1	1	1			2		5
Texas	1	8	6	123	15	14	6		1	174
Virginia			1	4	2	1		3		11
West Virginia			1							1
Washington, DC			2		2					4
Total	2	68	24	468	92	73	53	23	10	813

Review - To improve our responsiveness and analyses, working papers and partial drafts of many parts of the EIS were shared with cooperating agencies, working groups and citizens with special expertise throughout the process. Scientific adequacy was enhanced by these reviews. Section V.D lists reviewers and their affiliations. Unique qualifications of these people augment disciplines represented on the interdisciplinary team.

The draft EIS was mailed out for public review on May 16, 1988, with the notice of availability appearing in the June 3, 1988, Federal Register. Copies were sent to each of the 891 respondents, plus others known to have an interest or required by regulations. In all, about 1,900 copies of the draft EIS and 1,500 copies of the appendices were mailed. About 1,500 copies of the 15-page, separately bound summary were also mailed.

The comment period ended August 25, 1988. Comments were accepted at all Southern Region offices in writing, in person, or by phone. Comments received after the August 25 deadline were also fully considered. Comments ultimately totalled 348.

Content analysis was done on the 302 comments received by August 25. Of this total, 162 were exactly the same (duplicate post cards) and were addressed by a single response. Many comments contained several items about issues and aspects of vegetation management. Some expressed a preference for an alternative, often based on perceived effects on a specific environmental element (table VI-2). Some had several items about perceived adverse effects of methods analyzed in the EIS:

<u>No. of Items</u>	<u>Method</u>
132	Herbicides
23	Prescribed Fire
14	Mechanical
0	Manual

Most of these items concerned aerial application of herbicides (29) and effects on water (24), wildlife (23), and hardwoods (20); 26 were unspecified.

Of the 302 comments, 48 applauded the quality of analysis and 24 thought the EIS was well written. On the other hand, 15 criticized the analysis and 6 felt the writing style was too complex or dull.

Complete copies of all comment letters and Forest Service responses are found in volume III.

## **B. CONSULTATION WITH OTHERS**

One of the most important processes of preparing this EIS was information gathering. Advice and contributions from experts are essential to a thorough analysis. Chapter V lists nearly 100 individuals who contributed. In many cases authors of research papers were consulted to clarify results of their analyses. While all consultations helped shape the analysis, some resulted in specific direction on how to conduct it.

Table VI-2.--DEIS comments stating an alternative preference

Environmental Element	Alternative													
	A	A+B	B	C	Mod C	D	Mod D	E	Mod E	F	Mod F	G	Mod G	H
Not specified	6	2	5	10	1	6	1	7	1	2	1	19	2	2
Wildlife			2	1		5		2		1		4		
T&E				2				1				1		
Soil				1										1
Water			1	3		1		2				4		1
Diversity	1		1	2		2		2				2		
Health/Safety			1	1		2		1				2		
Economics			2	2				3				3		1
Multiple Use			1									7		1

Offices of the Environmental Protection Agency in Atlanta, Georgia and Washington, D.C. were consulted concerning analysis requirements, especially for water. They advised that cumulative effects be analyzed on typical watersheds. They also advised that analysis of sediment loads consider potential effects on quality of aquatic habitat. The analysis in chapter IV models cumulative watershed effects as advised, and considers effects on fisheries.

Dow Chemical Company was consulted regarding results of new tests on dermal penetration rates for triclopyr. These test results caused substantial revision of risk assessment.

The contractor responsible for preparation of the risk assessment, Labat-Anderson, Inc., routinely consulted with the Environmental Protection Agency regarding analytical protocol for the risk assessment, and to obtain toxicological information. Data resulting from these consultations are reflected in the risk assessment.



### C. LIST OF THOSE TO WHOM THIS DOCUMENT WAS SENT

#### Businesses

Adley Associates	Georgia Power
A. F. Clewell, Inc.	Georgia Timberlands
Agricultural Resources Center	Gulf Power Company
Ahimsa Techni	Gulf States Utilities
Alabama Power	John G. Guthrie & Sons
Alabama River Woodlands, Inc.	Hankins Lumber
Amerada Hess	Helena Chemical Co.
American Cyanamid	A. J. Hodges, Inc.
Anderson Manufacturing	International Paper
Anderson Tully Company	ITT Rayonier
Apalachee Forest Resource	Joe Jacobs Insurance
Consultants, Inc.	Kentucky Power
Appalachian Power	Kentucky Utilities
Architect Nehrbass Limited	Fred King Hunting Ranch
AR Consultants	Leaf River Forest Prod.
ARK Land Co.	Lewis Tree Service Inc.
Arkansas Louisiana Gas	Louisiana Pacific Corp.
Arkansas Power & Light	Mansville Forest Prod.
Asplundh Tree Expert	Roy O. Martin Lumber
Balfour Pulpwood	Mims Wood
Barc Electric	Mississippi Power & Light
Boise Cascade	Mitchell Electric Membership Corp
Boston Edison	Mobile Pipeline
Buckeye Cellulose	Monongahela Power
Canal Wood of Fitzgerald	Monsanto
Carolina Wilderness Adventures	Morton Manufacturing
Bobby Cauley, Inc.	MS Title Service
Central Alabama Electric	Munro Petroleum Terminal
Central Louisiana Power	National Foundation for the
Central Virginia Electric	Chemically Hypersensitive
Champion International	Northeast Utilities
Chem Spray North, Inc.	N.S.I. Inc.
Cities Service Oil and Gas	Oklahoma Gas & Electric
Columbia Gas Transmission Corp.	Owens Illinois
Conoco	Potlach
Curtis Land Co.	Potomac Edison
Dixie Electric Power	Powell Industries
Dixie Pipeline	Hubert Pelley Marine Sales
Dow Chemical	Resource Management Service
East Kentucky Power	Rocko Electric
Edward Reid, Software Consultant	Sam Houston Electric
E. I. Du Pont De Nemours & Co.	SC Electric & Gas
Elanco Products	Scott Paper Company
Environmental Services	Shenandoah Valley Electric
Estate of Wm. G. Helis	Sibley Lake Realty
Fairfield Electric	Southern Environmental Law Center
Florida Power	Southern Woodlands
Gee & Jenson, Inc.	Southwest Forest Industries
Georgia Pacific	Steely Lumber Co., Inc.
	St. Joseph Land Development
	Summit Helicopters

Sumter Electric  
Temple Eastex  
Tennessee Gas Pipeline  
Terra, Inc.  
Texas Utilities Electric  
Union Camp Corporation  
Valley Nursery  
Virginia Power  
Wainwright Engineering  
Warmack Lk.  
Weaver Land and Timber  
Westvaco  
Weyerhaeuser  
Willamette Timber

Colleges and Universities

Alabama A&M  
Alcorn State, MS  
Auburn, AL  
Clemson, SC  
Delaware State  
Duke, NC  
Florida A&M  
Fort Valley State, GA  
Furman, SC  
Harvard, MA  
Humboldt State, CA  
Kentucky State  
K&K Realty  
Langston, OK  
Lincoln, MO  
Louisiana State  
Louisiana Tech  
Mississippi State  
Natchitoches State, LA  
North Carolina A&T  
North Carolina State  
Northwestern, IL  
Oklahoma State  
Prarie View A&M, TX  
Roanoke, VA  
Rust, MS  
Slippery Rock State, PA  
South Carolina State  
Southern LA  
Southern Mississippi  
Stephen F. Austin, TX  
Tennessee State  
Texas A&M  
Tuskegee Institute, AL  
University of Alabama  
University of Arkansas

University of Florida  
University of Georgia  
University of Houston, TX  
University of Kentucky  
University of Maryland  
University of Mississippi  
University of North Carolina  
University of Pittsburg, PA  
University of Tennessee  
University of Washington  
University of Wisconsin  
Virginia Polytechnic Institute  
Virginia State  
Western Carolina, NC  
West Georgia  
West Virginia  
Yale, CT

Elected Federal Officials

Alabama

Howell Heflin  
Richard C. Shelby  
Tom Bevill  
Sonny Callahan  
Bill Dickinson  
Ronnie Flippo  
Claude Harris  
Bill Nichols

Florida

Lawton Chiles  
Bob Graham  
Bill Chappell, Jr.  
Bill Grant  
Earl Hutto  
Buddy MacKay  
Bill McCollum

Georgia

W. Wyche Fowler, Jr.  
Sam Nunn  
Charles F. Hatcher  
Pat Swindall  
John R. Lewis  
George W. Darden  
J. Roy Rowland  
Ed Jenkins  
D. Douglas Barnard

## Louisiana

J. Bennett Johnston  
John B. Breaux  
Charles E. Roemer  
Jerry Huckaby  
Clyde Holloway

## Mississippi

Thad Cochran  
John C. Stennis  
Wayne Dowdy  
Mike Espy  
Trent Lott  
G. V. Montgomery  
Jamie Whitten

## North Carolina

Jesse Helms  
Terry Sanford  
Walter Jones  
David E. Price  
Stephen Neal  
W. G. (Bill) Hefner  
Cas Ballenger  
James McClure Clarke

## South Carolina

Ernest F. Hollings  
J. Strom Thurmond  
Butler C. Derrick, Jr.  
Elizabeth J. Patterson  
Arthur Ravenel, Jr.  
Floyd D. Spence  
John M. Spratt, Jr.  
Robert M. Tallon, Jr.

## Texas

Steve Bartlett  
Lloyd Bentsen  
John Bryant  
Phil Gramm  
Joe Barton  
Jim Chapman  
Ralph M. Hall  
Charles Stenholm  
Charles Wilson  
Jim Wright

## Federal Agencies

Advisory Council on Historic  
Preservation - Washington, DC

Bureau of Reclamation - El Paso, TX  
Centers for Disease Control -  
Atlanta, GA

Delaware River Basins Commission - NJ  
Department of Agriculture

APHIS - Hyattsville, MD  
Office of Equal Opportunity -  
Washington, DC

Office of the General Counsel -  
Atlanta, GA - Ogden, UT -  
Washington, DC

Office of the Secretary -  
Washington, DC

Rural Electrification  
Administration - Washington, DC  
Soil Conservation Service -

AL, FL, GA, LA, NC, TX, Washington, DC

Department of Commerce

National Marine Fisheries  
Service - FL

National Oceanic & Atmospheric  
Administration - Washington, DC

Department of Defense

Department of the Air Force  
AFRCE-CR/ROV - TX -  
Englehard, NC

Department of the Army  
Fort Polk, SC

Corps of Engineers - Mobile,  
AL - Washington, DC  
Wilmington, NC

U.S. Marine Corps  
Camp LeJeune

Marine Corps Base - Quantico, VA

Department of the Interior

Bureau of Land Management -  
Alexandria, VA

Bureau of Mines - Washington, DC

Bureau of Reclamation - Denver, CO  
Fish and Wildlife Service -

Annapolis, MD - Asheville, NC -  
Atlanta, GA - Fort Worth, TX -  
Nacodoches, TX - Raleigh, NC -  
Daphne, AL - Lafayette, LA -  
Brunswick, GA

Geological Survey - Tuscaloosa, AL

National Park Service - Daviston,  
AL - Gatlinburg, TN - Harpers

Ferry, WV - Louisville, KY -  
Philadelphia, PA - Tupelo, MS -  
Washington, DC

Office of Environmental Review -  
Albuquerque, NM - Washington, DC -  
Atlanta, GA



Department of Transportation

Federal Highway Administration -

Atlanta, GA - Baltimore, MD -

Baton Rouge, LA - Columbia, SC -

Fort Worth, TX - Tallahassee, FL

Environmental Protection Agency -

Atlanta, GA - Dallas, TX - New York,

NY - Philadelphia, PA - Washington, DC

Equal Employment Opportunity

Commission - Washington, DC

Federal Energy Regulatory Commission -

Washington, DC

International Boundary & Water Commission

National Endowment for the Arts -

Washington, DC

Occupational Safety & Health

Administration - Washington, DC

Small Business Administration -

Atlanta, GA

Southwestern Power Administration - OK

Tennessee Valley Authority - TN

Individuals

Abell, Barbara

Abernathy, Wilford, L.

Adams, David A.

Adams, John A., Jr.

Adams, John A.

Adams, Mark W.

Adams, Reginald D.

Adkins, Gladys

Aery, Dorothy

Ahearn, Walter T.

Alexander, William H.

Alfiero, Richard

Allbritton, Robert M.

Allen, Arthur

Aller, Chuck

Allison, Jim

Allred, George E.

Ambuske, Robert F.

Anderson, C. E.

Anderson, Charles

Anderson, Florence

Anderson, Steven

Anderson, Virginia D.

Apgar, William

Aplin, Lorita

Apple, Robert E.

Arinder, Clifton L.

Armentrout, Bob

Arnbal, Anders K.

Arner, Dale

Arnold, Edward E., Sr.

Arrowood, Cathy

Arthur, Giles B.

Ashworth, Jerry

Ayers, James W.

Bailey, Tommy L.

Baker, Alen D.

Baker, James

Baker, Robert D.

Baker, Scottie

Baker, W. Wilson

Balboni, Michael L.

Baldridge, Dave

Baldwin, John

Ball, Charles Dean

Ball, Michelle D.

Baltie, Tony J.

Baranski, Michael J.

Barber, Mrs. W. C.

Barden, Charles J.

Barden, Larry

Barefoot, Charles A.

Barker, Milton E., Jr.

Barnes, Sam

Barnette, Phil

Barr, Thomas C., Jr.

Barrett, Jerry

Barrett, Morley L.

Barrett, Willie W.

Bass, Stuart

Bassinou, Dr. E. A.

Bates, Richard J.

Battle, Oscar K., Jr.

Baxter, Norman W.

Beachy, Paul

Becker, Bruce

Belanger, Susan

Belangia, C. O.

Belt, George H., Sr.

Bennett, Lawton

Bennett, N. I.

Bennett, Nancy M.

Bennett, Ralph M.

Berlanda, Jack J.

Bernett, Barbara

Bernett, Dean

Besold, Henry

Bethancourt, Don

Biglane, Nancy K.

Billetdeaux, Susan H.

Billion, Rodney

Bingham, Hoyle

Birch, Harold B.

Bitner, Delano Eugene

Black, Mrs. Arthur

Blackwell, Charles W.

Blaine, Ray

Blair, Lane

Blocker, Nelson

Bobbitat, Charles

Bolt, Martin G.

Bonar, Kent  
 Bookout, Karen, Tom & Brett  
 Booth, Carl  
 Booth, Edie  
 Boothby, Johnson  
 Borders, Gene  
 Boswell, L. G.  
 Bounds, John H.  
 Bousquet, Woodward S.  
 Bow, Catherine C.  
 Bowling, Dale Ray  
 Boyce, Stephen G.  
 Bezanson, Janice  
 Brabham, Robert  
 Brantley, Christopher G.  
 Brantly, Robert M.  
 Brashear, Everett  
 Braswell, Allen  
 Braun, Ron  
 Bray, Earl  
 Bray, Jack  
 Breazeale, Jimmy Riley  
 Breen, D. N.  
 Breland, Keith A.  
 Brent, M. Thomas  
 Brevelle, Carl J.  
 Bridges, R. L.  
 Brimberry, Kate E.  
 Brinson, Robert  
 Brooks, Robin  
 Broussard, Allan J.  
 Brower, Don L.  
 Brown, Angus  
 Brown, Bob  
 Brown, Deb  
 Brown, F. H.  
 Brown, M. J.  
 Brown, Matthew  
 Brugger, Kristin  
 Brunell, Arnold M.  
 Bruner, Marlin H.  
 Bryan, Dana C.  
 Buckner, Edward R.  
 Buckner, James V.  
 Bugh, Ernest B.  
 Burkart, David  
 Burkes, Danny L.  
 Burleigh, John R.  
 Burnett, Howard  
 Burns, Anna  
 Burns, Eloise  
 Burton, Mary  
 Bush, Parshall

Byrd, Nathan A.  
 Cain, Jimmy D.  
 Caire, Michael J.  
 Caldwell, Carrie  
 Callahan, Jack N.  
 Callery, Caroline & Charles  
 Cameron, Viola M.  
 Carnes, James T.  
 Carnes, Sandy  
 Carpenter, Janella Ann  
 Carpenter, Douglas M.  
 Carr, Majorie  
 Carroll, Bill  
 Carroll, Wayne D.  
 Carter, J. H.  
 Cartwright, Alfreddie  
 Cartwright, James B.  
 Cartwright, T. C.  
 Cascio, Gary  
 Cason, Randy W.  
 Cassard, David  
 Cassell, Howell  
 Chambliss, Erwin B.  
 Chang, M  
 Charest, Bert  
 Charles, D. W.  
 Chevis, Edward G.  
 Chumbley, Lola  
 Chumbley, Mose  
 Cibula, William  
 Clark, Brian  
 Clark, Gary  
 Clarkson, Don  
 Clede, Bill  
 Clegg, John J.  
 Clement, D. A.  
 Clewell, Andre F.  
 Clouser, R. L.  
 Coker, Richard H.  
 Coleman, Elizabeth  
 Coleman, Lee  
 Collom, Ralph M.  
 Colvin, Thagard R.  
 Conner, Richard N.  
 Conner, Bob  
 Conner, Elizabeth  
 Conner, Laura  
 Connor, Buddy W.  
 Conoway, Kathy  
 Cook, Mary D.  
 Cooper, Jerome  
 Cornelius, Don  
 Costello, Tom

Covington, James R.  
 Cox, R. W.  
 Crawford, Michael H.  
 Crews, Wayne J.  
 Cristman, Steve  
 Cronn, James W.  
 Crumheller, Philip McC.  
 Cunningham, M. L.  
 Cunningham, Peyton, Jr.  
 Curry, Mary G.  
 Curtis, Robert L.  
 Cuthbert, Peter  
 Cutler, Richard  
 Cywinski, Raymond J.  
 D'Oriocourt, Bryan  
 Dahmus, Loretta  
 Daland, Robert T.  
 Dale, Edwin  
 Daley, Ed  
 Darnell, Donnie  
 Davenport, Bruce C.  
 Davenport, Sandy  
 Davids, H. E.  
 Davidson, Jib A.  
 Davis, Anse Mack  
 Davis, Jerry W.  
 Davis, Joel Henry  
 Davis, Vicki J.  
 Dawson, James C.  
 Debrunner, L. Earl  
 Decker, George R.  
 DeJanes, Sherry  
 Delemar, James C.  
 Dematties, Joseph  
 Devall, Margaret S.  
 Diblick, A. V.  
 Dickey, W. M.  
 Dillahunt, Dennis D.  
 Dixon, Bob  
 Dixon, Charles  
 Dockery, Alex  
 Doerr, P. D.  
 Dooley, James E.  
 Doss, Martha A.  
 Dougherty, Phillip M.  
 Doyle, Gerry  
 Draper, Harold  
 Drumheller, Philip M.  
 Drummond, Margaret  
 Dudley, George W.  
 Duffy, Roberta M.  
 Dunlap, Ron  
 Dunn, B. Allen

Dunnuck, Tom  
Dutch, Margaret  
Dutrow, George  
Duzan, Steven L.  
Dwinell, Steven E.  
Earnest, J. Chris  
Easton, Rick  
Edmondson, Edwin W.  
Edmonson, Gary  
Edmonson, Joseph  
Edwards, Malcolm G.  
Eitel, Elaine  
Elam, Bob  
Eling, Timothy W.  
Elliott, R. P.  
Ellis, David  
Elsen, Dean  
Elsner, Norman R.  
Ely, Austin L.  
Ely, Elizabeth A.  
Emery, Edith A.  
Englehart, Mark  
Epperly, Sheryan P.  
Ernst, Charles F.  
Erwin, Kevin L.  
Esher, Robert J.  
Estes, John H.  
Estes, Sue H.  
Evans, Azilda  
Evans, John  
Evans, Michael  
Evans, Rob R.  
Evans, S. B., Jr.  
Ewald, William  
Ewel, Katherine  
Fanning, Marsha E.  
Farmer, Jerome  
Fayard, Henry M.  
Ferguson, Clyde A. B.  
Fieselma, C.  
Finch, Ray E.  
Findley, Frank  
Fish, Herb  
Fish, Steven  
Fisher, Carol Ann  
Fitzmayer, Bob  
Flake, Harold W.  
Fleming, Johnny  
Fletcher, John M.  
Fletcher, Marylynn L.  
Fondren, Matt  
Forbes, Donovan C.  
Forbes, Joy

Forbs, A. S.  
Forster, Robert W.  
Forsythe, Tom  
Fort, E. B.  
Fortier, Billy  
Foster, Williams S.  
Fountain, Michael S.  
Fowler, Ian K.  
Fowler, Norma L.  
Fowler, Thomas  
Fox, Walter  
Franks, Douglas  
Fraser, Thomas E.  
Freemark, Kathy  
Frick, Margaret  
Friedrich, Allan  
Frossard, Woody  
Frost, Cecil  
Frye, Mrs. Russell  
Fulgham, Charlie B.  
Gaddy, L. L.  
Gaitanis, Louis A.  
Galloway, Joe C.  
Galsby, Roswell P.  
Gandy, Jay  
Gardner, Joel  
Gardner, William  
Garner, L.  
Garrett, L. M.  
Gault, William J.  
Gay, Julian D.  
Gaydosh, Robert J.  
Gaylord, Julia L.  
Geisendorff, Nathan E.  
Geisler, James C.  
Germain, Rene Henri  
Gerry, Bob  
Gibson, Mark W.  
Gilchrist-Young, Daun  
Gish, James R.  
Gist, Howard B., III  
Gnegy, Jack  
Goertz, John W.  
Goodyear, Bob  
Gowan, Claude A.  
Graham, Barbara W.  
Graham, Charles  
Graham, Dick  
Graham, Michael  
Graham, Thomas P.  
Graves, A. L.  
Greer, John L.  
Gregar, Norman P.

Gregory, James D.  
Griffith, Edith M.  
Griffith, Robert L.  
Griffitt, Keith  
Grimm, B. A.  
Grushinski, Ed  
Guthrie, J. William  
Gwynn, Donna  
Hagler, Chris  
Hair, J. D.  
Hale, John C.  
Hale, Wayne  
Haley, Curtis R.  
Hall, Ralph E.  
Hallman, Ronnie  
Hamann, Richard  
Hamilton, John M.  
Hamm, Bernice  
Hammond, Crickett  
Hampton, Fran  
Hancock, G. Nicholas  
Hansbourough, Thomas  
Hardin, John D.  
Hardy, Ray  
Hargraves, L.  
Harman, Jerry E.  
Harmon, Eloise  
Harmon, Frank  
Harms, Bill  
Harper, George Lea, Jr.  
Harris, Finis L.  
Harrison, Jack A.  
Hart, Robin  
Hartfield, Paul  
Hartman, John  
Hasty, Gary  
Haviland, R. P.  
Hawk, Robert T.  
Hawkins, Marsha  
Hawkins, W. Michiel  
Hayes, Lark  
Haygreen, James H.  
Healy, Tom  
Hebert, Bambi  
Hehr, B.  
Heiland, Sharyn  
Hendler, Richard J.  
Herbert, Allen  
Herman, Richard  
Herrick, Tom  
Herzog, Carl H.  
Hess, William  
Heyd, Bob



Hicks, Lee M.  
 Hier, Mrs. S. T.  
 Hiers, R.  
 Hightower, Fred  
 Hihn, Don E.  
 Hill, Isaiah  
 Hill, Peggy  
 Hill, Robert W.  
 Hilliard, John R.  
 Hinchee, Janet K.  
 Hines, Randy Kevin  
 Hines, Richard E.  
 Hinkle, Robert C.  
 Hiss, Maynard  
 Hitt, James  
 Hodges, Donald Glenn  
 Hodges, John D.  
 Hoelscher, James E., Jr.  
 Hogan, Joe  
 Holcombe, Edwin F.  
 Hollander, Alex  
 Holler, Gary W.  
 Hollingsworth, Paul  
 Hollinsworth, Natalie J.  
 Hopenwasser, Alan  
 Hopkins, Wesley  
 Horakova, Zdenka Z.  
 Horn, Charles N.  
 Horn, Wayne D.  
 Horton, Billy R.  
 Horton, R. C.  
 Hosner, J. F.  
 Hotsenpiller, Mark  
 Hotvedt, J. E.  
 Hough, Marshall J.  
 Howard, Donna B.  
 Howard, H. E.  
 Hudgins, Mr. & Mrs. Thomas S.  
 Hugh, J. A.  
 Hughes, Rickey E.  
 Humphrey, David  
 Hunter, Jeff  
 Hutchens, James B., Jr.  
 Hutchins, Bennie F.  
 Hutchison, Inge S.  
 Hyder, Brian  
 Imhof, John Michael  
 Imhof, Thomas  
 Ince, Peter J.  
 Irwin, John G.  
 Irwin, R. F.  
 Isaacs, Donna L.  
 Isaacs, Faye

Isenhour, Charles E.  
 Jackson, Don  
 Jackson, James R.  
 Jackson, Jerome A.  
 Jacobs, R. C.  
 Jaden, Bhaskar B.  
 Jamieson, Mickey  
 Jarobe, James  
 Jeffries, James A. & Mary L.  
 Jervis, Larry G.  
 Jevons, Deryl  
 Joe, Bohunk  
 Johns, Robert B.  
 Johnson, C. Heath  
 Johnson, Earl  
 Jones, Bill  
 Jones, Dan  
 Jones, Dennis E.  
 Jones, Jay B.  
 Jones, Johnny  
 Jones, Tommie L.  
 Jordan, Jim  
 Jordan, Judy  
 Joslin, Ruth  
 Juneau, E. J.  
 Kahle, Robert  
 Karr, Bob L.  
 Karr, Joan F.  
 Katibah, G. M.  
 Kearney, Lewis  
 Kearns, Howard O.  
 Keel, Freddie  
 Kehler, Lynn  
 Keith, Tiffany  
 Keller, John E.  
 Kellett, R. W.  
 Kelley, Donna  
 Kelley, J. David  
 Kellison, Robert  
 Kelly, E. J.  
 Kelly, Thomas H.  
 Kendall, Jane C.  
 Kenebrook, Mary A. Van  
 Ketcham, Red  
 Kilian, Leonard A., Jr.  
 Kinard, Fred W.  
 King, Carol  
 King, Charles N.  
 King, Clarence F., Jr.  
 Kinsey, Alva D., Jr.  
 Kirkland, Red  
 Kirkwood, R.  
 Kitler, Steven J.

Kittle, Paul  
 Knierim, Kathleen D.  
 Knight, Bill  
 Kobrin, Susan  
 Kockenmeister, H.  
 Koenig, James F.  
 Kohlmeier, Jan  
 Koier, Bill  
 Kramer, U. L.  
 Krochmal, Arnold  
 Krochmal, Connie  
 Kroneberg, Carole  
 Kruse, Dwayne  
 Kutack, Jason N.  
 Kveton, Roy G.  
 Kushner, Adele  
 Kyle, Water  
 Lacour, Henry J., Jr.  
 Ladner, R. L.  
 Lake, Ken  
 Lamb, Mrs. Guy L.  
 Land, Samuel B., Jr.  
 Land, Tommie Gene  
 Landers, Larry  
 Landin, Mary C.  
 Landrum, J. C.  
 Langford, Lyndon L.  
 Langham, Mr. & Mrs. Robert  
 Langley, Jack  
 Langston, Stephen A.  
 Lanier, Lisa  
 Lankford, Jayne L.  
 Larson, Dave  
 Latham, Richard L.  
 Lawrence, Colonel R. L.  
 Lawson, Edwin R.  
 Layne, Cheryl  
 Layssard, Charles R.  
 Layssard, Maidie  
 Lebr, Mrs. Roy B.  
 Lee, Bob  
 Lee, Jimmy  
 Lee, Jinny Maureen  
 Legg, Michael H.  
 Leh, James  
 Lelong, Michel G.  
 Lemay, James H.  
 Lewis, William Hoke  
 Lightsey, Liz  
 Lilley, G. D.  
 Lincer, Jeffrey L.  
 Lindsey, Carl  
 Lindsey, Penny

Lister, C. H.  
 Lister, Vinnie  
 Little, Janea M.  
 Little, Mack  
 Little, Roy A.  
 Little, T. D.  
 Livesay, Marcia W.  
 Lodrige, Joseph L.  
 Long, Beverly H.  
 Long, Chris  
 Long, Walter K.  
 Longer, Allen W.  
 Longshore, Jennie  
 Loo, Wade T.  
 Loomis, Louise  
 Lott, Phoebe Jane  
 Louallen, Ricky  
 Lowery, Robert  
 Lu, Po-Yung  
 Luper, James H.  
 Luscher, Doug  
 Lutenbacher, Mark G.  
 Mabry, Larry G.  
 MacFarlane, Robert  
 Maddux, Thomas L.  
 Madrulli, Gertrude F.  
 Madrulli, Robert P.  
 Maggi, Rich  
 Maguire, Mike  
 Mahagan, John K.  
 Mahan, William E.  
 Main, Alden C.  
 Maltbie, Dorothy P.  
 Mangan, Becky  
 Mann, Nace C.  
 Mannchen, Brandt  
 Maple, William R.  
 Markeloff, Robert  
 Martel, Jean-Pierre  
 Martin, H. E.  
 Martin, J. M.  
 Martin, William H.  
 Masters, David A.  
 Mather, Charles M.  
 Matthews, Gary W.  
 Matsuiak, Constance  
 McAfee, Hugh B  
 McAfee, Laura  
 McAfee, Salle E.  
 McAlpin, Thomas  
 McBride, David A.  
 McCaa, James P.  
 McCarthy, A. H.

McCarthy, Garland  
 McCaughan, Russell  
 McClarren, Greg R.  
 McClinton, H. F.  
 McClurkin, Charles C.  
 McCorquodale, Mack  
 McCoy, Kathryn C.  
 McCrone, John  
 McDavid, Raymond H.  
 McDowell, G. W.  
 McGinty, Douglas T.  
 McGrady, Charles W.  
 McGuire, Diane  
 McIntyre, Paula  
 McKee, Bill  
 McKim, Eleanor  
 McKim, Robert L.  
 McLane, Bryant  
 McLane, M. I.  
 McLaughlin, Beverly  
 McLeod, George K.  
 McMahon, Charles  
 McNeil, Odea V., Jr.  
 McWhorter, Van  
 McWilliams, Will  
 Mead, James  
 Mead, Ruth  
 Meadows, J. S.  
 Means, D. Bruce  
 Meekins, W. L., Sr.  
 Meier, Calvin E.  
 Melchiors, Tony  
 Melick, Ross  
 Merriott, J. Frost  
 Messina, Michael G.  
 Michael, Jerry  
 Mielke, Lewis H.  
 Mikell, Richard B.  
 Millar, Richard H.  
 Miller, Abe  
 Miller, Leo  
 Miller, Martha  
 Miller, Michael A.  
 Miller, Patrick  
 Miller, Peter H.  
 Miller, Rick L.  
 Miller, W. Frank  
 Milliff, Matt  
 Mitchell, Bob  
 Mitchell, Ronald L.  
 Mize, Floyd H.  
 Mobley, Edgar  
 Montgomery, Jane R.

Montgomery, Mrs. Roger  
 Moore, Jerome  
 Moore, John W.  
 Moore, Kraig Lawrence  
 Moorman, Charles  
 Morgan, Gloria  
 Morgan, H. C., Jr.  
 Morgan, Ricky E.  
 Morgan, Robert  
 Morin, Joe  
 Morrill, William  
 Morrow, Marla Sue  
 Morse, Eleanor  
 Moseley, Bill  
 Moulton, Paula T.  
 Mrazek, Bill  
 Mrazek, Lynda  
 Mulholland, Fred W.  
 Muller, Robert A.  
 Murdoch, Marianne  
 Murphy, Sue A.  
 Murray, James R.  
 Mustian, A. P., Jr.  
 Myer, Karen  
 Myers, J. Walter, Jr.  
 Nahikian, Nick  
 Nance, M. M., Jr.  
 Napier, Harris  
 Naylor, James F., Jr.  
 Nehrbass, Janet H.  
 Nelson, Larry  
 Nelson, Thomas A.  
 Nelsyn, Wade  
 Nguyen, Ben  
 Nichols, Robert  
 Nicholson, Albert R.  
 Noland, Stewart  
 Norman, James E.  
 Norris, Logan  
 Ochsner, Herbert E.  
 Ogden, Jane  
 Oglesbee, J. H.  
 O'Laughlin, Jay  
 Oliveria, Forrest L.  
 Olsen, Orland S., Jr.  
 Olson, John M.  
 O'Neal, James N.  
 Oravec, Eugene V.  
 Oren, Ram  
 O'Rourke, Tere  
 Orr, Patricia  
 O'Toole, Randal Lee  
 Overstreet, Garlen

Oviatt-Lawrence, Alice  
 Owen, Leon D.  
 Owens, Cheryl  
 Owens, John V.  
 Owens, Nancy L.  
 Owsijuk, Art  
 Owsijuk, Valerie  
 Packee, Edmond C.  
 Padgett, James R.  
 Page, Lavon B.  
 Palmer, Elige  
 Papania, Ken  
 Paradise, Brian  
 Parham, Glen  
 Parker, Mr. & Mrs. Cordray  
 Parker, Tim A.  
 Parks, Peter  
 Parrish, Allie Ruth  
 Paschal, Lawrence W., Jr.  
 Paul, Michel N.  
 Pawelczyk, Harry T.  
 Payne, James L., Jr.  
 Paynter, Ken  
 Paysinger, C. T.  
 Peck, Henry  
 Penland, David  
 Pennington, Roy M.  
 Perdue, L. Donovan  
 Perkins, Bretta  
 Petrick, Edity W.  
 Phillips, James  
 Phillips, Marsha  
 Phillips, T. G.  
 Pickering, Mike  
 Piles, Pauline  
 Pinckard, Gerald W.  
 Pitts, Howard  
 Pitts, Kenny  
 Poindexter, Mr. & Mrs. Richard  
 Polley, James  
 Poole, James F.  
 Poole, Lane G.  
 Pope, Bill  
 Porterfield, Dick  
 Porthro, Nancy  
 Poth, Christopher  
 Potts, J. D.  
 Powell, Joyce  
 Powell, Peggy  
 Prewitt, Terrell G.  
 Price, Charles S.  
 Pullen, Thomas M., Jr.  
 Quivoz, Andrew

Ragsdale, Susan  
 Ragsdale, Walter  
 Ratto, David B.  
 Raulston, Marvin E.  
 Ray, Blaine  
 Ray, Hurlon C.  
 Raymond, Larry R.  
 Raymond, Lynn  
 Raynes, Martin  
 Reasor, J. Dan  
 Reed, Eldon H.  
 Reed, Helen T.  
 Reels, David Mark  
 Reice, Seth  
 Reich, Robert S.  
 Reichardt, Lowell K., Sr.  
 Reid, Elberta G.  
 Reid, Melynda Claire  
 Reid, Robert R., Jr.  
 Remmers, Galen H.  
 Renebrook, Phyllis Van  
 Renwick, George  
 Retan, J. Walden  
 Rex, Merrill R.  
 Richard, Jack R.  
 Richards, Paul W.  
 Richardson, Curtis J.  
 Richardson, Jack  
 Richter, Dan  
 Rigsby, A. G.  
 Ripley-Hager, Brian K.  
 Rippeteau, Bruce E.  
 Rivers, Martin E.  
 Roberts, Walter  
 Robbins, Louise  
 Robertson, Dennis  
 Robinson, Kent  
 Robinson, Michael C.  
 Rockwood, Don  
 Rod, E. F.  
 Roddy, Jane  
 Rodgers, Elizabeth B.  
 Rodriguez, Lorraine D.  
 Rollock, Kenneth  
 Roos, John W.  
 Root, Carolyn D.  
 Rosemier, Dick L.  
 Ross, J. L.  
 Rousseau, Dick  
 Rowe, Hugh D.  
 Rowe, Sandra  
 Runk, Christopher  
 Runkle, John D.

Runner, Frances W.  
 Russell, Michael W.  
 Ryan, Ted  
 Ryan, William  
 Ryerson, Richard D.  
 Saldaner, Mrs. Thomas  
 Salinas, Ana  
 Sammons, M. L.  
 Sanchez, J.  
 Sanders, Gregory L.  
 Sapp, Joe E.  
 Sarb, Pat  
 Saucier, Joseph M.  
 Saunders, Shell  
 Sawyer, Don  
 Scarborough, Jeff  
 Scarborough, Ruth  
 Schary, Richard  
 Schauer, Jacob M.  
 Scheidler, Jane  
 Schell, Kerry F.  
 Schemnitz, S. D.  
 Schmidt, D. M.  
 Schneider, Rachel G.  
 Schwartz, Cindy S.  
 Schwartz, Jay R.  
 Scott, Gilbert  
 Secord, Reed  
 Sell, Clark  
 Selman, Joseph  
 Shankman, David  
 Sharpe, Terry  
 Sheffer, Dale E.  
 Shelton, Larry D.  
 Shepard, Mike  
 Sherrod, John  
 Short, Shelton H.  
 Showalter, George B.  
 Shupe, Brian  
 Simmons, Jane  
 Simmons, Sedgwick  
 Simpson, Dwayne H.  
 Sjerven, Barbara  
 Smart, Charles W.  
 Smistik, Robert  
 Smith, Archer D.  
 Smith, Archer D., Jr.  
 Smith, Bobby Coy  
 Smith, Donna  
 Smith, Ed L.  
 Smith, Gary S.  
 Smith, Herrick H.  
 Smith, I. G.



Smith, James D.  
Smith, Royce  
Smith, Truett  
Smith, W. J.  
Smith, Walton R.  
Smotherman, L. B.  
Snipes, Robert L.  
Snow, Susan  
Solomon, Mike  
Somers, Ann B.  
Somers, George W.  
Sonnenfeld, J.  
Sparnight, Roderick E.  
Spraggins, Robin Lee  
Spurgen, Steven  
Staff, Michael D.  
Stafford, Nancy I.  
Stahl, David E.  
Stalling, Dick  
Standish, Michael  
Starr, Arnold  
Stebor, Anderson  
Steitz, Henry E.  
Stelman, Teresa M.  
Stephens, Robert E.  
Stephenson, Joey  
Stevenson, Walter H.  
Stewart, Gene D.  
Stewart, Jimmy, Sr.  
Stewart, Robert A.  
Stewart, William P.  
Still, Hugh R.  
Stirewalt, Martha  
Stokes, Mickey A.  
Story, Patty  
Stout, Jack  
Strader, Robert W.  
Stradt, Tom H.  
Strange, Gerald  
Sullins, Jessie  
Sundheimer, Paul W.  
Svetlik, Alice  
Svetlik, Claire  
Svetlik, Martha Beaty  
Swanson, Grace G.  
Swanson, John R.  
Swanzy, Jim  
Swindell, T. C.  
Swindle, Archie  
Swindle, Ranzie  
Swindle, Roosevelt  
Swindle, Zephaniah  
Switzer, George L.

Taber, David W.  
Tadlock, June  
Talton, Bobby O.  
Taylor, Helen T.  
Taylor, Horace A.  
Taylor, James  
Taylor, John N.  
Taylor, Nelson  
Taylor, W. B.  
Tebo, Mary E.  
Templeton, Beverly  
Teska, Bill  
Teston, Gary W.  
Thiede, Sam  
Thielges, Bart  
Thill, Ronald E.  
Thomas, Charlie A.  
Thomas, Paul O.  
Thomas, R. Dale  
Thomas, William R., Jr.  
Thompson, Bryan  
Thompson, David  
Thompson, Emmett  
Thompson, Forrest S.  
Thompson, Jesse C.  
Thorn, Jerry  
Tindall, N. L.  
Toon, Leon  
Townsend, Janet  
Trew, I. F.  
Trotter, George W.  
Troxell, Robert L.  
Trotty, Ike  
True, M. G.  
Tucker, Gary  
Uehling, Edward R.  
Ursic, Stan J.  
Vandersteen, Charles A.  
Vanfosson, Ralph F.  
Van Lear, David  
Van Wyck, Roger C.  
Veilleux, Tom  
Vessels, Jimmie  
Vidrine, Levie  
Vigerstad, Torgny  
Voigts, David K.  
Voth, Richard D.  
Wade, Michelle C.  
Wade, Suzanne  
Waeste, J. T.  
Waggoner, Keith B.  
Walbridge, Mark  
Waldep, Melinda M.

Waldrop, Tom  
Ward, Ray O.  
Ward, Russell  
Warneke, Bob Jr.  
Warneke, Jean  
Warny, Peter R.  
Warren, Robert J.  
Warrick, Duane  
Waterhouse, Joe  
Watkins, Marvin H.  
Watson, Dale L.  
Watson, Ray  
Watt, Donald R.  
Watterson, Kenneth G.  
Weaver, Barry  
Weaver, David  
Weaver, Robert H.  
Weaver, Stephen P.  
Weber, Judith  
Weber, Richard  
Weisner, William W.  
Welborn, Jim  
Wells, Carolyn  
Welsh, John F.  
Westphal, Joanne  
Whaley, O. Clodene  
Whidden, Arden L.  
White, Donald H.  
White, H. W.  
White, J. C.  
White, Robert  
Whiteside, Susan Stamas  
Whitetrifaro, Linda  
Whitmore, Roy  
Whitney, Charles G.  
Wiggs, Tim  
Wilhite, F. Ross  
Wilkinson, Ron  
Willard, George P.  
William, Alva B.  
Williams, Elmer & Nellie  
Williams, George J.  
Williams, Jerry  
Williams, Lawrence T., Jr.  
Williams, Robert F.  
Williams, Robert T.  
Williams, R. Trent  
Willis, Lee E.  
Willis, Michael  
Wilson, Dorothy C.  
Wimmer, Mary  
Winfree, Vance  
Winkelmann, Roy K.

Winkler, Fred  
Wise, Arlow  
Wise, Raye  
Wofsy, Sheila  
Wood, Anna Faye  
Wright, Harry R.

Wright, Judith  
Wright, Richard C., Jr.  
Wyman, Doris  
Yocum, Eric S.  
Young, Charles H.  
Zabana, Deborah

Zedaker, Shep  
Zeschke, Ruth  
Ziegler, Kelly  
Ziegler, Mary  
Zlotsky, Amy  
Zontek, Frank

### Libraries

Bureau of Land Management  
Central Florida Regional  
Colorado State University  
Florida State University  
International Paper  
International Paper Research  
Kimberly - Clark  
Louisiana Collection  
Rapides Parish  
Rocky Mountain Station Library  
SOUTHFORNET  
Univ. of North Florida  
USDA National Agricultural  
WESTFORNET  
WESTVACO - FSL  
Weyerhaeuser Research Center  
Weyerhaeuser SFRC

### Media

Gordon Baxter, Freelance  
The Clarion Ledger, MS  
Denton-Record, NC  
The Florida Cattleman  
The Independent  
LA Femme Newspaper, FL  
News and Record, NC  
Richmond Times Dispatch, VA  
The Times, NC  
WVMF/WLKF Radio, FL

### Minority Organizations

Black Chamber of Commerce, AR  
Cheyenne-Arapaho Business Comm.  
Chitimacha Tribal Council  
Creek Nation of OK  
Eastern Band of Cherokee Indians  
Houston Area Urban League  
NAACP, FL  
NAACP, GA  
NAACP, SC

National Urban League, GA  
OIC - Opportunity Industrial, GA  
OTOE - Missouri Business Comm., OK  
Pawnee Business Council, OK  
Potawatomi Business Comm., OK  
Quapaw Business Comm., OK  
Tonkawa Business Comm., OK  
Urban League of AR

### Organizations

Alabama Conservancy  
Alabama Conservation - Federated Clubs  
Alabama Forestry Association  
Alabama Garden Clubs  
Alabama Ornithological Society  
American Camping Association  
American Forest Council  
American Motorcycle Association  
American Orchid Society  
American Petroleum Institute  
American Plywood Association  
American Pulpwood Association  
American Society of Landscape  
Architects  
Americanism Foundation  
Animal Rights Kinship  
Appalachian Consortium  
Appalachian Trail Conference  
Arkansas Forestry Association  
Audubon Society  
Balsam Highlands Task Force  
Bonnet Carre Rod and Gun  
Carteret Wildlife Club  
Charleston Natural History Society  
Citizens Environmental Council - VA, TX  
Claiborne Hunt and Fishing Club  
Common Sense Army  
Conservation Council of NC  
Earth First! - FL, TX, VA  
Environmental Defense Fund - NY  
Environmental Law Institute  
Farm Bureau - MS, TX  
Florida Defenders of the Environment  
Florida Dog Hunters Association

Florida Forestry Association  
 Florida Native Plant Society  
 Florida Trail Association  
 Forest Farmers Association  
 Forest Service Timber Purchasers  
 Foundation for NC Archaeology  
 Friends of the Mountains  
 Georgia Forestry Association  
 Gopher Tortoise Council  
 Institute of Government  
 International Forestsearch  
 Izaak Walton League - NC, VA  
 John Rob Fork Hunt Club  
 Keep Kisatchie Coalition  
 Land-of-Sky Regional Council  
 Leaf River Deer Club  
 Louisiana Forestry Association  
 Manasota - 88  
 Mississippi Forestry Association  
 National Association of Conservation  
 District  
 National Audubon Society - Baton Rouge,  
 LA - Bay County, FL - Charleston, SC - Dallas,  
 TX - Nacodoches County, TX - Naples, FL -  
 Austin, TX  
 National Campers and Hikers Association  
 National Forest Products Association  
 NCASI  
 National Wildlife Federation -  
 AL, DC, MS  
 National Wild Turkey Federation -  
 FL, NC, SC  
 Nature Conservancy - FL, GA, NC,  
 SC, VA  
 Neuse River Foundation  
 North Carolina Environmental Defense Fund  
 Ozark Society  
 Public Awareness Committee Inc.  
 Sabine - San Augustine Landowners  
 San Jacinto Forest Landowners  
 Sierra Club - Arkansas Chapter -  
 Athens, GA - Cahaba Group -  
 Conservation Council - Delta Chapter  
 - Central Piedmont - Florida -  
 Kisatchie Group - Legal Defense  
 Fund - Lone Star Chapter -  
 North Carolina - South Carolina -  
 South Central States Office  
 Society of American Foresters  
 South Carolina Forestry Association  
 Southeast Fisheries Council  
 Southern Forest Products Association  
 South Mississippi Sportsman

Swan View Coalition  
 Tall Timbers Research  
 Texas Conservancy Coalition  
 Texas Conservation Foundation  
 Texas Commission on Natural Resources  
 Texas Endurance Riders Association  
 Trees for Tomorrow  
 Trinity Forest Landowners Association  
 Trout Unlimited - GA - Fisherville,  
 VA - Vienna, VA  
 Walker County Forest Landowners  
 Association  
 Western North Carolina Alliance  
 Wildlife Management Institute -  
 TN, TX, DC  
 Wildlife Society - FL, NC  
 Yale Forest Management Study Group  
 YMCA - Southeast Region

#### State and Local Government - Alabama

Cooperative Extension Service  
 Department of Conservation and Natural  
 Resources  
 Forestry Commission  
 Game and Fish Division  
 Historical Commission  
 State Conservation Officer  
 St. Clair County Board of Education  
 Talladega Water and Sewage  
 Town of Brookside

#### State and Local Government - Arkansas

Cooperative Extension Service  
 Forestry Commission

#### State and Local Government - Florida

Apalachee Regional Planning Commission  
 Appalachicola Research Reserve, DNR  
 City of Ormond Beach  
 City of Tallahassee  
 Cooperative Extension Service  
 Department of Environmental Regulation  
 Department of Natural Resources  
 Department of Transportation  
 Division of Forestry  
 East-Central Regional Planning Commission  
 Game and Fresh Water Fish Commission  
 Governor's Office  
 Lake County Pollution Control  
 Lake County Water Authority



Natural Areas Inventory  
NE Regional Planning Council  
NW Water Management District  
SW Water Management District  
Town of Ponce Inlet

State and Local Government - Georgia

Cooperative Extension Service  
Department of Natural Resources  
Forestry Commission  
Natural Heritage Inventory

State and Local Government - Kentucky

Cooperative Extension Service  
Division of Forestry

State and Local Government - Louisiana

Air Control Commission  
Cooperative Extension Service  
Department of Agriculture & Forestry  
Department of Culture, Recreation and  
Tourism  
Department of Environmental Quality  
Department of Wildlife and Fisheries  
Office of Forestry - DNR  
Office of Water Resources - DEQ

State and Local Government - Maryland

Cooperative Extension Service

State and Local Government - Mississippi

Bureau of Pollution Control, DNR  
City of Rolling Fork  
Cooperative Extension Service  
Department of Wildlife Conservation  
Forestry Commission  
Highway Department  
Military Department  
Oil and Gas Board  
Southwest EPA  
State Clearinghouse

State and Local Government - North Carolina

Botanical Garden  
Carteret County  
City of Beaufort  
City of Marion

Cooperative Extension Service  
Craven County  
Dept of Administration  
Dept of Agriculture  
Division of Parks and Recreation  
Division of Forest Resources  
Maritime Museum  
Mecklenburg County Parks and Recreation  
NRCD - Coastal Management  
NRCD - Natural Heritage Program  
NCRD - Parks & Recreation  
NCRD - Project Review Coordination  
NRCD - Water Resources  
Plant Conservation Program  
State Clearinghouse  
State Historic Preservation Officer  
State Museum of Natural Science  
Western Piedmont Council of Governments  
Wildlife Resources Commission

State and Local Government - Oklahoma

Cooperative Extension Service  
Forestry Division

State and Local Government - Pennsylvania

Pennsylvania Dept. of Transportation

State and Local Government - South Carolina

Cooperative Extension Service  
Dept of Health & Environmental Control  
Forestry Commission  
Heritage Trust  
Land Resources Commission  
Newberry Soil and Water Conservation  
District  
Parks, Recreation and Tourism  
Wildlife and Marine Resources Department

State and Local Government - Virginia

Cooperative Extension Service  
Council on the Environment  
Department of Forestry

State and Local Government - Tennessee

Cooperative Extension Service  
Division of Forestry

State and Local Government - Texas

Attorney General, EPD  
Cooperative Extension Service  
Dept of Agriculture  
Dept of Highways  
Dept of Transportation  
Forest Service  
Harris County Flood Control District  
Houston County  
Parks & Wildlife Dept  
Parks and Wildlife Dept  
San Augustine County  
Shelby County  
Walker County  
Wise Soil and Water Conservation  
District





# Glossary

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## CHAPTER VII

### GLOSSARY

**Active ingredient (a.i.).**--The effective part of a pesticide formulation, or the actual amount of the technical material present in the formulation.

**Acute toxicity.**--The toxicity of a compound when given in a single dose or in multiple doses over a period of 24 hours or less. The quality or potential of a substance to cause injury or illness shortly after exposure to a relatively large dose.

**Adjuvant (additive).**--Something added to the pesticide mixture to help the active ingredient do a better job. Examples: wetting agent, spreader, adhesive, emulsifying agent, penetrant.

**a.i.**--See Active ingredient.

**Allelopathic.**--Pertaining to the suppression of growth of one plant species by another through the release of toxic substances.

**Amine.**--Any of a group of organic compounds of nitrogen, such as ethylamine,  $C_2H_5NH_2$ , that may be considered ammonia derivatives in which one or more hydrogen atoms have been replaced by a hydrocarbon radical.

**Animal unit month (AUM).**--The amount of feed or forage required by an animal unit for one month.

**Annual (plant).**--A plant species living and growing for only 1 year or season.

**Aquifer.**--An underground zone of earth or rock saturated with water whose upper limit is the water table.

**AUM.**--See Animal unit month.

**Biennial (plant).**--A plant species that completes its life cycle, from seed germination to seed production, in 2 years. Also means "to occur every 2 years," as in biennial burns.

**Bioaccumulation.**--The process of a plant or animal selectively taking in or storing a persistent substance. Over a period of time, a higher concentration of the substance is found in the organism than in the organism's environment.

**Biological control.**--Pest control without the use of chemicals. Parasites, predators, diseases, etc. are used to control pests.



**Biological opinion.**--An official report by the Fish and Wildlife Service (FWS) or the National Marine Fisheries Service (NMFS) issued in response to a formal Forest Service request for consultation or conference. It states whether an action is likely to result in jeopardy to a species or adverse modification of its critical habitat.

**Biomass.**--The total amount (weight) of living material in a given habitat.

**Broadcast application.**--Uniform distribution of an herbicide over an entire area.

**Broadleaf weed.**--A nonwoody dicotyledonous plant with wide bladed leaves designated as a pest species in gardens, farms, or forests.

**Browse.**--That part of leaf and twig growth of shrubs, woody vines, and trees on which browsing animals can feed; to consume browse.

**Buffer strip.**--A strip of vegetation that is left unmanaged or is managed to reduce the impact that a treatment or action on one area would have on an adjacent area.

**Canopy.**--The cover of branches and foliage formed collectively by the crowns of adjacent trees and other woody growth.

**Carcinogenic.**--Producing or inciting cancer.

**Chemical degradation.**--The breakdown of a chemical substance into simpler components through chemical reactions.

**Chronic toxicity.**--How poisonous a pesticide is to an animal (or man) after small, repeated doses over a period of time.

**Class I area.**--One of three classes of areas provided for in the Clean Air Act for the Prevention of Significant Deterioration program. Class I areas are the "cleanest" area and receive special visibility protection. They are allowed very limited increases (increments) in concentrations of regulated pollutants in the ambient air over baseline concentrations. (See 42 U.S.C. 7473 for description of the specific increments).

**Conifer.**--An order of the Gymnospermae, comprising a wide range of trees, mostly evergreens that bear cones and have needle-shaped or scalelike leaves; timber commercially identified as softwood.

**Deciduous.**--Pertaining to any plant organ or group of organs that is shed naturally; perennial plants that are leafless for some time during the year.

**Diversity.**--The distribution and abundance of different plant and animal communities and species within the area covered by a land and resource management plan.

**Dose.**--The amount of chemical administered or received by an organism, generally at a given point in time.

**Drift.**--That portion of a sprayed chemical that is moved by wind off a target site.

**Duff.**--The lower portion of the organic layer covering the soil, consisting of decomposed litter.

**Ecological niche.**--The physical space in a habitat occupied by an organism; its functional role in a community; and its position in environmental gradients of temperature, moisture, pH, soil, and other conditions of existence.

**Ecosystem.**--The system formed by the interaction of a group of organisms and their environment.

**Ecotone.**--The place where plant communities meet or where successional stages of vegetative conditions within plant communities come together; for example, a forest edge.

**Edge.**--The more or less well-defined boundary between two or more elements of the environment; for example, field/woodland.

**Endangered species.**--Any species that is in danger of extinction throughout all or a significant part of its range. Endangered species must be designated in the Federal Register by the appropriate Secretary. (See Threatened species.)

**Ephemeral stream.**--A stream that flows less than 10 percent of the time, only in direct response to rainfall, with a channel that may be scoured or unscoured and is always above the water table.

**Ester.**--A compound formed by the reaction of an acid and an alcohol, generally accompanied by the elimination of water.

**Exposure.**--The amount of contact with a pesticide.

**FIFRA.**--Federal Insecticide, Fungicide and Rodenticide Act (1948, amended 1972, 1975, 1978).

**Forage.**--All browse and nonwoody plants available to livestock or wildlife for grazing or harvested for feed.

**Forb.**--Any herbaceous plant other than grass or grasslike plants.

**Foreground.**--A term used in visual resource management to describe the visible terrain in which individual details of the landscape can be perceived, usually up to 1/4-1/2 mile from the observer.

**Formulation.**--The form in which a pesticide is packaged or prepared for use. A chemical mixture that includes a certain percentage of active ingredient (technical chemical) with an inert carrier.

**Fuel.**--Living or dead plant material that will burn.

**Habitat.**--The natural environment of a plant or animal. An animal's habitat includes the total environmental conditions for food, cover, and water within its home range.

**Half-life.**--The time required for half the amount of substance (such as a herbicide) in or introduced into a living system to be eliminated whether by excretion, metabolic decomposition, or other natural process.

**Hazard.**--The risk of danger; the chance that danger or harm will come to the applicator, bystanders, consumers, livestock, wildlife or crops, etc.

**Herbaceous.**--A plant that does not develop persistent woody tissue above the ground (annual, biennial, or perennial), but whose aerial portion naturally dies back to the ground at the end of a growing season. Herbaceous plants include such categories as grasses, grass-like (sedges, rushes), and forbs.

**Herbicide.**--A chemical used to control, suppress, or kill plants, or to severely interrupt their normal growth processes.

**Hydrolysis.**--Decomposition or alteration of a chemical substance by water.

**Inert ingredients.**--All ingredients in a formulated pesticide product which are not classified as active ingredients. Note that inert as used here is a defined usage; many inert products are biologically active chemicals.

**Intermittent Stream.**--A stream that flows seasonally (10-90 percent of the time) in response to a fluctuating water table, with a scoured channel that is at least 3 feet wide.

**Karst.**--Topography formed on limestone or other soluble rock and characterized by sinkholes, caves, and underground drainage.

**Label.**--All printed material on or attached to a pesticide container as required by law.

**Landtype.**--A land area with distinct topography, geology, and runoff-erosion response to management.

**LC<sub>50</sub>.**--See Lethal concentration<sub>50</sub>.

**LD<sub>50</sub>.**--See Lethal dose<sub>50</sub>.

**Lethal concentration<sub>50</sub>(LC<sub>50</sub>).**--The concentration of a chemical at which 50 percent of the test animals will be killed. It is usually used in testing of fish or other aquatic animals.

**Lethal dose<sub>50</sub>(LD<sub>50</sub>).**--Median lethal dose, is the milligram of toxicant per kilogram of animal body weight (mg/kg) lethal to 50 percent of the test animals to which it is administered under the conditions of the experiment.

Median lethal dose, is the milligram of toxicant per kilogram of animal body weight (mg/kg) lethal to 50 percent of the test animals to which it is administered under the conditions of the experiment.

**Litter.**--The upper portion of the organic layer covering the soil, consisting of unaltered dead remains of plants and animals whose original form is still visible.

**Margin of safety (MOS).**--The ratio between the animal no observed effect level (NOEL) and the estimated human dose. The larger the MOS, the smaller the estimated human dose and the lower the risk to human health.

**Meristem.**--The growing point or area of rapidly dividing cells at the tip of a stem, root, or branch.



**Microbial degradation.**--The breakdown of a chemical substance into similar components by bacteria.

**Mitigation Measure.**--An action taken to lessen adverse impacts or enhance beneficial effects.

**Multiple use.**--The management of all the various renewable surface resources of the National Forest System so that they are utilized in the combination that will best meet the needs of the American people; making the most judicious use of the land for some or all of these resources or related services over areas large enough to provide sufficient latitude for periodic adjustments in use to conform to changing needs and conditions; that some lands will be used for less than all of the resources, each with the other, without impairment of the productivity of the land, with consideration being given to the relative values of the various resources, and not necessarily the combination of the uses that will give the greatest dollar return or the greatest unit output.

**Mutagenicity.**--The capacity of a substance to cause changes in genetic material.

**National Environmental Policy Act (NEPA).**--Establishes a national policy to encourage productive and enjoyable harmony between man and the environment, to promote efforts that will prevent or eliminate damage to the environment and stimulate the health and welfare of man, to enrich the understanding of the ecological systems and natural resources important to the nation, and to establish a Council on Environmental Quality.

**National forest land and resource management plan.**--A plan developed to meet the requirements of the Forest and Rangeland Renewable Resources Planning Act of 1974, as amended (95-125, 129, 130). This plan guides all natural resource management activities, and establishes management activities, standards, and guidelines for each national forest.

**Natural regeneration.**--The renewal of a tree crop by natural means, or without efforts to seed or plant trees. The new trees grow from self-sown seeds or by vegetative means such as root suckers.

**NEPA.**--See National Environmental Policy Act.

**NOEL.**--See No-observed-effect-level.

**Nontarget.**--Any plant, animal, or other organism that a method application is not aimed at, but may accidentally be injured by the method.

**No-observed-effect-level (NOEL).**--In a series of dose levels tested, it is the highest level at which no effect is observed.

**Noxious weed.**--A plant regulated or identified by law as being undesirable, troublesome, and difficult to control.

**Oncogenicity.**--Capable of producing or inducing tumors in animals, either benign (noncancerous) or malignant (cancerous).

**Opportunity cost.**--The net loss, expressed in dollars, resulting from the selection of a less efficient course of action.

**Perennial.**--A plant species having a lifespan of more than 2 years.

**Perennial stream.**--A stream that flows year-round (more than 90 percent of the time) with a scoured channel that is always below the water table.

**Persistence.**--The resistance of a herbicide to metabolism and environmental degradation and thus a herbicide's retention of its ability to kill plants for prolonged periods.

**Pesticide.**--Any substance or mixture of substances intended for controlling insects, rodents, fungi, weeds, or other forms of plant or animal life that are considered to be pests.

**Photodecomposition.**--The breakdown of a substance, especially a chemical compound, into simpler components by the action of radiant energy.

**Photosynthesis.**--Formation of carbohydrates in the tissues of plants exposed to light.

**Plant community.**--An association of plants of various species found growing together in different areas with similar site characteristics.

**Pocosin.**--An evergreen shrub bog on a raised plateau, usually removed from large streams yet periodically flooded, with acid, poor sandy or peat soils, in the Atlantic flatwoods (Algonquin: "swamp on a hill").

**Poison.**--Any chemical or agent that can cause illness or death when eaten, absorbed through the skin, inhaled, or otherwise absorbed by man, animals, or plants. Note that a substance is a poison or not with respect to specific organisms. Animals safely eat many things which are "poisonous" to humans.

**Precommercial thinning.**--Cutting in immature stands to improve the quality and growth of the remaining stand. None of the felled trees are extracted and utilized.

**Protocol.**--see Standard.

**Pyrolysis.**--Chemical breakdown caused in the process of combustion.

**Regeneration.**--The renewal of a tree crop whether by natural or artificial means. Also, the young crop itself.

**Release and weeding.**--All work done to free desirable trees from competition with overstory trees, less desirable trees or grasses, and other forms of vegetative growth. It includes incidental disease control work and release of natural and artificial regeneration.

**Residue.**--The quantity of a herbicide or its metabolites remaining in or on soil, water, plants, animals, or surfaces.

**Rhizomes.**--A stem, generally modified for storing food materials, that grows along and below the ground surface and that produces adventitious roots, scale leaves, and suckers irregularly along its length, not just at nodes.

**Riparian ecosystem.**--A transition between the aquatic ecosystem and the adjacent terrestrial ecosystem which is identified by soil characteristics and distinctive vegetation communities that require free or unbound water.

**Risk.**--The probability that a substance will produce harm under specified conditions.

**Risk analysis.**--The description of the nature and often the magnitude of risk to organisms, including attendant uncertainty.

**Rotation.**--The number of years required to establish and grow a timber crop to a specified condition of maturity. The rotation includes a period for harvesting and stand re-establishment, usually 5 years.

**Safety factor.**--A factor conventionally used to extrapolate human tolerances for chemical agents from no-observed-effect levels in animal test data.

**Savannah.**--A flat, treeless grassland of tropical or subtropical regions.

**Scoping.**--The process by which significant issues relating to a proposal are identified for environmental analysis. Scoping includes eliciting public comment on the proposal, evaluating concerns, and developing alternatives for consideration.

**Sensitive Species.**--Those plant and animal species identified by a Regional Forester for which population viability is a concern, as evidenced by: significant current or predicted downward trends in population numbers or density; or significant current or predicted downward trends in habitat capability that would reduce a species' existing distribution.

**Shrub.**--A plant with persistent woody stems and relatively low growth form; usually produces several basal shoots as opposed to a single bole; differs from a tree by its low stature and nonarborescent form.

**Silviculture.**--The branch of forestry dealing with the care, development, and reproduction of forest trees or stands of timber.

**Site preparation.**--The removal of competition (including woody slash) and conditioning of the soil to enhance the survival and growth of seedlings or to enhance the germination of seed.

**Snag.**--A standing dead tree.

**Species (plural: species).**--A morphologically, genetically, and ecologically defined biological entity to which a binomial and authority is given; e.g., Potamogeton filiformis Pers., the slender-leaf Potamogeton.

**Stand.**--Trees that grow in the same location, and which are fairly uniform in type, age and risk classes, vigor, stand-size class, and stocking class. The similarity of these qualities distinguish the stand from adjacent stands that contain trees with different features.

**Standard.**--A principle requiring a specific level of attainment; a rule to measure against.



**Subchronic.**--The effects observed from doses that are of intermediate duration, usually 3 months.

**Succession.**--The progressive development of trees or other plants toward their highest role in their ecology; their climax. The replacement of one forest, or other plants, by others.

**Technical chemical or pesticide.**--The pesticide as it is first manufactured by the company before formulation. It is usually almost pure.

**Teratogenesis.**--The development of abnormal structures in an embryo.

**Threshold.**--A dose or exposure below which there is no apparent or measurable adverse effect.

**Threshold limit value (TLV).**--The concentration of an airborne constituent to which workers may be exposed repeatedly, day by day, without adverse effect.

**Timber stand improvement (TSI).**--Activities conducted in young stands of timber to improve growth rate and form of the remaining trees, includes release and precommercial thinning.

**TLV.**--See Threshold limit value.

**Toxicity.**--A characteristic of a substance that makes it poisonous.

**TSI.**--See Timber stand improvement.

**Understory (vegetation).**--Shade-tolerant plants growing below the canopy of other plants. Usually refers to grasses, forbs, and low shrubs under a tree or brush canopy.

**Visual resource.**--The composite of basic terrain, geologic features, water features, vegetative patterns, and land-use effects that typify a land unit and influence the visual appeal the unit may have for visitors.

**Watershed.**--The entire area that contributes water to a stream or lake.

**Wetlands.**--Those areas that are inundated by surface or ground water often enough to support plants and other aquatic life that requires saturated or seasonally saturated soils for growth and reproduction. Wetlands generally include swamps, marshes, bogs and similar areas such as sloughs, potholes, wet meadows, river overflows, mud flats, and natural ponds.

**WSI.**--See Wildlife Stand Improvement.

**Wildlife Stand Improvement (WSI).**--Activities conducted in timber stands to improve conditions for various wildlife species. Includes release and midstory removal.

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## CHAPTER VIII

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